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PATTERNS OF DISTRIBUTION AND ECOLOGICAL CHARACTERISTICS OF RARE FLORA SPECIES IN THE TERRITORY OF KOKSHETAU STATE NATIONAL NATURAL PARK

The article examines the distribution patterns and ecological characteristics of rare flora species within the territory of the Kokshetau State National Natural Park. The relevance of the study is justified by the need to assess the population status of plant species included in the Red Data Book of the Republic of Kazakhstan and to preserve biodiversity.

The aim of this study is to identify the spatial distribution patterns of rare plant species within the territory of the park's five branches, analyze their ecological groups, and assess the level of floristic similarity between the territories.

The scientific significance of the work lies in specifying the distribution areas of rare species at the levels of forestry units, quarters, and plots, as well as in providing a comprehensive assessment of the structure of rare flora.

As a result of the study, 13 rare species were identified, including 11 species of higher plants, one lichen, and one moss. The distribution areas of the rare species were specified at the level of forest management quarters and plots and were mapped using cartographic materials. In assessing floristic similarity, the highest similarity was found between the Zerendi and Arykbalyk branches ($J = 0.75$), while the lowest similarity was characteristic of the Shalkar and Ayrtau branches ($J = 0.17$). The ecological analysis showed that the majority of species belong to hygrophytes, mesophytes, and xeromesophytes, indicating the widespread presence of forest-steppe and wetland ecosystems within the park. All the studied species belong to Category III of the Red Data Book of Kazakhstan. The results of the study make an important contribution to the conservation of rare flora species, the implementation of monitoring, and the scientifically based management of specially protected natural areas.

Keywords: Red Book, Kokshetau National Park, flora, rare plants, floristic similarity, ecological groups.

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«Көкшетау» МҰТП аумағындағы флораның сирек түрлерінің таралу заңдылықтары және экологиялық сипаттамасы

Мақалада «Көкшетау» мемлекеттік ұлттық табиғи паркі аумағындағы флораның сирек түрлерінің таралу заңдылықтары мен экологиялық сипаттамасы қарастырылған. Зерттеудің өзектілігі Қазақстан Республикасының Қызыл кітабына енгізілген өсімдік түрлерінің популяциялық жағдайын бағалау және биоалуантүрлікті сақтау қажеттілігімен негізделеді. Бұл зерттеудің мақсаты – парктің бес филиалы аумағында сирек өсімдіктердің кеңістіктік таралу ерекшеліктерін анықтау, олардың экологиялық топтарын талдау және аумақтар арасындағы флоралық ұқсастық деңгейін бағалау. Жұмыстың ғылыми маңызы сирек түрлердің таралу аймақтарын орманшылық, орам және телім деңгейінде нақтылауымен және сирек флора құрылымына кешенді баға беруімен сипатталады. Зерттеу нәтижесінде 13 сирек түр анықталып, олардың 11-і жоғары сатыдағы өсімдіктерге, 1-і қынаға және 1-і мүкке жататыны анықталды. Сирек түрлердің таралу аймақтары орман шаруашылығы орамдары мен телімдері деңгейінде нақтыланып, картографиялық материалдарға түсірілді. Флоралық ұқсастықты бағалауда ең жоғары ұқсастық

Арықбалық филиалдары арасында ($J=0,75$) анықталса, ең төмен көрсеткіш Шалқар мен Айыртау филиалдарына тән болды ($J=0,17$). Экологиялық талдау нәтижесінде түрлердің басым бөлігі гигрофиттер, мезофиттер және ксеромезофиттер екені анықталып, парк аумағында орманды-дала және сулы-батпақты экожүйелердің кең таралғанын көрсетті. Барлық зерттелген түрлер Қазақстанның Қызыл кітабының III санатына жатады. Зерттеу нәтижелері флораның сирек түрлерін сақтау, мониторинг жүргізу және ерекше қорғалатын табиғи аумақтарды ғылыми негізде басқару ісіне маңызды үлес қосады.

Түйін сөздер: Қызыл кітап, Көкшетау МҰТП, флора, сирек өсімдіктер, флоралық ұқсастық, экологиялық топтар.

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Закономерности распространения и экологическая характеристика редких видов флоры на территории ГНПП «Кокшетау»

В статье рассматриваются закономерности распространения и экологическая характеристика редких видов флоры на территории Кокшетауского государственного национального природного парка. Актуальность исследования обусловлена необходимостью оценки популяционного состояния видов растений, занесённых в Красную книгу Республики Казахстан, и сохранения биоразнообразия.

Целью исследования является выявление пространственных особенностей распространения редких растений в пределах пяти филиалов парка, анализ их экологических групп и оценка уровня флористического сходства между территориями. Научная значимость работы заключается в уточнении ареалов редких видов на уровне лесничеств, кварталов и выделов, а также в комплексной оценке структуры редкой флоры.

В результате выявлено 13 редких видов, из которых 11 относятся к высшим растениям, 1 к лишайникам и 1 к мхам. Места произрастания редких видов уточнены на уровне лесохозяйственных кварталов и выделов и нанесены на картографические материалы.

При оценке флористического сходства установлено, что наибольший показатель отмечен между Зерендинским и Арықбалықским филиалами ($J=0,75$), наименьший — между Шалқарским и Айыртауским филиалами ($J=0,17$). Экологический анализ показал преобладание гигрофитов, мезофитов и ксеромезофитов, что свидетельствует о широком распространении лесостепных и водно-болотных экосистем. Все выявленные виды относятся к III категории Красной книги Казахстана.

Результаты исследования вносят значительный вклад в сохранение редких видов флоры, организацию мониторинга и научно обоснованное управление особо охраняемыми природными территориями.

Ключевые слова: Красная книга, ГНПП Кокшетау, флора, редкие растения, флористическое сходство, экологические группы.

Abbreviations and designations

SNNP – State National Natural Park, IUCN – International Union for Conservation of Nature.

Introduction

Today, the conservation of biodiversity and the efficient management of natural resources are among the global environmental priorities. In the Republic of Kazakhstan, this direction is implemented at the state level in accordance with the National Development Plan of the Republic of Kazakhstan until 2029,

approved by Presidential Decree No. 611 dated July 30, 2024, signed by the President K.K. Tokayev [1]. The strategic importance of this document lies in increasing the share of specially protected natural areas and introducing an ecosystem-based approach. This approach includes ecosystem monitoring, environmental risk assessment, and restoration of degraded habitats.

The main tool for protecting rare and endangered flora species is the Red Book of the Republic of Kazakhstan [2]. At the international level, species status is regulated by the IUCN Red List, European Union directives, and the Bern Convention.

For example, species such as *Pulsatilla patens* are classified as strictly protected taxa under these international documents [3-5].

The flora diversity of Kazakhstan includes 5658 vascular plant species [6], among which the level of endemism is high (760 species) [7]. Currently, 387 plant species are under state protection [2].

The territory of the Kokshetau SNNP plays a strategically important role in preserving the biodiversity of the Northern Kazakhstan. According to the scientific passport of the park, 597 species of higher plants (98 families, 324 genera) have been recorded there [8]. The formation and structure of the regional flora have been thoroughly analyzed in the works of Sh.N. Durmekbayeva [9-11] and D. Alibekov, S.A. Kubentaev and others for Akmola region [12]. Researchers emphasize the necessity of continuous monitoring of rare taxa populations such as *Diphysastrum complanatum*, *Spinulum annotinum*, *Drosera anglica*, and others.

According to scientific literature, the reduction in the number of rare species is directly influenced by anthropogenic transformation and climate change. European studies (for example, on *Adonis vernalis*) show a significant contraction of peripheral populations over the last five centuries [13-14]. In addition, disruption of the hydrological regime threatens species such as *Nymphaea alba*, *Nuphar luteum*, and *Drosera rotundifolia* in wetland ecosystems [15, 16-19].

Peatland and bog ecosystems play an important role in the carbon cycle; however, their degradation leads to increased CO₂ emissions and weakening population stability of plants such as *Oxycoccus palustris* and *Sphagnum* spp. [20]. The population decline of *Stipa pennata*, which serves as an indicator species of xerothermic conditions, is also associated with habitat narrowing [21].

Thus, fragmentation of ecosystems, degradation of habitats, and disturbance of the hydrological regime weaken the stability of rare plant populations. Species with narrow ecological amplitude and high dependence on specific biocenoses are particularly sensitive to external factors. Therefore, comprehensive study of the population status, spatial distribution, and ecological characteristics of plants included in the Red Book of the Republic of Kazakhstan is one of the priority scientific directions of nature conservation in Kazakhstan.

Modern scientific approaches to flora research are not limited to recording species composition but also include determining their ecological groups, analyzing kenotic relationships, and assessing dis-

tribution patterns using quantitative indicators. In particular, mapping the distribution of rare species, estimating population density, and applying floristic similarity coefficients (such as the Jaccard index) make it possible to determine ecological proximity or differences between territories. This provides a scientific basis for planning conservation measures at the territorial level.

The aim of the study is to identify distribution patterns of rare plant species listed in the Red Book within the territory of the Kokshetau SNNP, map their locations, analyze ecological characteristics, and assess floristic similarity levels to scientifically substantiate nature conservation measures.

The scientific novelty of the research lies in the clarification and cartographic systematization of the distribution of rare flora species within the park territory at the level of forest management blocks and compartments. In addition, comparative quantitative assessment of floristic similarity was used to determine differences in biodiversity structure among the park's branches.

Thus, the conducted study is aimed at conserving rare flora species in the Kokshetau SNNP, ensuring the stability of their populations, and forming a scientific basis for the effective management of specially protected natural areas.

Materials and methods

The objects of the study were plant species included in the Red Data Book growing within the territory of the Kokshetau SNNP. The Kokshetau SNNP is one of the specially protected natural areas of Kazakhstan, where floristic diversity is of particular importance. The park territory is divided into five branches: Arykbalyk, Shalkar, Zerendi, Ormandybulak and Aiyrtau.

Photographs of rare plant populations were taken during the study. Field research was carried out using route-area survey methods and according to the methodology of A.I. Tolmachev (1986) [22]. Plant identification and description were conducted using the following references: Flora of Kazakhstan, Vols. 1-9 (1956-1967) [23], Key to Plants of Central Asia [24], and Flora of Kazakhstan (1999) [25]. Ecological groups of plants were determined according to the classification of A.P. Shennikov [26]. All rare species and their conservation status were identified according to the Red Data Book of the Republic of Kazakhstan (2014) [2].

The locations of protected plant species were recorded using GPS coordinates. Plant species were

photographed using a Canon EOS 550D digital camera. Floristic similarity was determined using a methodology based on the Jaccard index [27]. Analysis of floristic similarity is used to identify ecological similarities or differences between floristic communities. This method allows for the assessment of plant distribution patterns, their ecosystem relationships, and the influence of various factors on biodiversity.

The Jaccard index (1) is used to measure similarity between two communities based on the number of shared species:

$$S_{Jaccard} = \frac{a}{a + b + c} \quad (1)$$

where:

a – number of species common to both communities;

b – number of species found only in the first community;

c – number of species found only in the second community.

Results and discussions

During the study, 13 plant species included in the Red Data Book of Kazakhstan were identified within the study area. Among them, 11 species are vascular plants, 1 species is a lichen, and 1 species is a moss.

According to their taxonomic composition, the identified species belong to the following families: *Ranunculaceae* – 4 species, *Orchidaceae* – 3 species, *Nymphaeaceae* – 1 species, *Poaceae* – 1 species, *Ericaceae* – 1 species, *Droseraceae* – 1 species, *Cladoniaceae* – 1 species, and *Sphagnaceae* – 1 species.

The precise distribution sites of the identified species were determined according to the forestry blocks and plots, and these data were incorporated into specialized cartographic materials.

These results not only clarify the spatial distribution of rare species but also provide an opportunity to monitor their population status and conduct long-term ecological monitoring. Based on the cartographic materials obtained, the ecological requirements of rare plant species, their growth conditions, and their adaptation to anthropogenic impacts were evaluated.

Mapping the precise distribution areas of the Red Data Book plant species represents an important component of conserving the flora of the Kokshetau

SNNP. This approach provides a scientific basis for the effective implementation of biodiversity conservation strategies and for ensuring the stability of natural ecosystems in the future. In addition, these data are important for the digitalization of plant resources within the park territory carried out as part of the project.

Below, the distribution areas and ecological characteristics of the Red Data Book plant species growing within the Kokshetau SNNP are analyzed, and photographs as well as excerpts from maps of their habitats are presented.

1. *Pulsatilla flavescens* (Zucc.) Juz. (Fig. 1).

A perennial herbaceous plant belonging to the family *Ranunculaceae* Juss.

Geographical distribution: The species occurs in the steppe and forest-steppe zones of Eurasia. In Kazakhstan it is mainly distributed in Northern and Eastern Kazakhstan, including the Kokshetau Upland, Karkaraly, Bayanaul, and steppe areas of Kostanay region, as well as within the territories of the Burabay and Kokshetau SNNPs.

Ecology: The species grows on dry and semi-dry meadow-steppe slopes, on rocky and gravelly soils, and along the edges of pine-birch forests. It is a light-demanding and cold-resistant mesophyte.

Economic importance: Medicinal, ornamental, and melliferous plant.

Conservation status: Included in the Red Data Book of Kazakhstan (Category 5). The species is considered recovered; however, its populations require continuous monitoring.

Locations recorded within the Kokshetau SNNP: Arykbalyk branch:

Karaultobe forestry – block 1, plot 1; block 4, plot 6; block 6, plot 3; block 9, plots 6, 12, 14; block 10, plot 14; block 16, plots 6, 10; block 19, plot 15; block 25, plots 4, 5, 10; block 28, plot 16. Leykovskoye forestry – block 45, plot 6; block 46, plots 27, 29; block 57, plots 11, 15. Torgai forestry – block 50, plot 21. Tomenge Burlyk forestry – block 87, plot 15; block 90, plots 33, 34, 35; block 91, plot 2; block 92, plot 24; block 95, plots 22, 23, 25. Aiyrtau branch: Syrimbet-Tukti forestry – block 10, plot 10; block 35, plot 57; block 42, plot 40. Sh. Ualikhanov forestry – block 160, plots 14, 15, 17, 18. Zerendi branch: Gribnovskoye forestry – block 41, plots 25, 32; block 63, plot 12; block 77, plots 18, 24; block 79, plot 6; block 93, plots 8, 9, 13. Zerendi forestry – block 51, plot 7; block 55, plot 3; block 57, plot 11; block 58, plots 14, 20; block 75, plot 4; block 202, plot 12. Zhylany forestry – block 15, plots 2, 3; block 27, plot 10.

Shalkar branch: Akan-seri forestry – block 48, plots 34, 51, 53, 57; block 52, plots 5, 6, 25. Shalkar forestry – block 32, plot 18; block 57, plots 17, 20, 22, 23; block 58, plots 47, 48, 49; block 59, plots 17, 30;

block 60, plots 7, 11, 16. Kostobe forestry – block 72, plot 36. Ormandybulak branch: Ormandybulak forestry – block 27, plot 1; block 28, plot 24; block 29, plots 27, 29; block 89, plot 9.

Figure 1

Pulsatilla flavescens (Zucc.) Juz. (A) and *Pulsatilla patens* (L.) Mill. (B), habitats (Karaultobe forestry – block 19, plot 15; Leykovskoye forestry – block 57, plot 16)



2. *Pulsatilla patens* (L.) Mill. (Fig 1).

It is a perennial herbaceous plant belonging to the family Ranunculaceae Juss.

Geographical distribution. The species is typical of the forest-steppe and steppe zones of Eurasia. In Kazakhstan, it is widely distributed in the Kokshetau Upland, Karkaraly, Bayanaul, Zerendi, Ereymentau, North Kazakhstan, Akmola and Pavlodar regions, as well as within the territory of the Kokshetau SNNP and Burabay National Nature Park.

Ecology. The species grows on the edges of pine–birch forests, dry meadow-steppe slopes, sandy and light soils. It is a light-demanding mesophyte and blooms in early spring (April–May).

Economic importance. Medicinal and ornamental plant.

Conservation status. The species is included in the Red Book of the Republic of Kazakhstan as a rare species (Category 3). The population of the species is highly sensitive to excessive anthropogenic factors.

Locations within the Kokshetau MNP territory: Arykbalyk branch: Leikovskoye forestry – block 46, plot 27; block 57, plot 16. Zerendi branch: Gribnovskoye forestry – block 61, plot 19; block 93,

plots 8, 9, 13; Zerendi forestry – block 55, plot 3; block 58, plots 16, 30. Shalkar branch: Akan-seri forestry – block 51, plots 3, 7, 8, 12; Shalkar forestry – block 42, plot 48; Kostobe forestry – block 86, plot 39; block 90, plot 39.

Pulsatilla flavescens is mainly distributed on steppe and rocky dry slopes and has yellowish flowers, whereas *Pulsatilla patens* is more common along forest edges and sandy soils and is characterized by beautiful pale purple flowers. Both species are early spring ephemerals, play an important ecological role, and are highly sensitive to anthropogenic pressure, which is why they are included in the Red Book of Kazakhstan.

3. *Cladonia rangiferina* (L.) F.H.Wigg. (Fig. 2)

A perennial shrub-like lichen belonging to the family Cladoniaceae.

Geographical distribution: A cosmopolitan species. Widely distributed in the Northern Hemisphere: grows in Arctic, tundra, taiga, and forest-steppe zones. In Kazakhstan, it is found in northern and eastern regions, especially in pine forests, on sandy and acidic soils. It is widely distributed in the territory of Kokshetau and Burabay SNNPs (SNNP).

Ecology: Grows in open areas with acidic soil, in coniferous forests, on sand dunes, and rocky slopes. Mesoxerophyte, light-loving (photophilous). As a ground-covering species, it plays an important role in stabilizing soil in forest ecosystems. Due to its sensitivity to pollutants (especially SO_2 and heavy metals), it is used as a natural indicator showing the quality of atmospheric air.

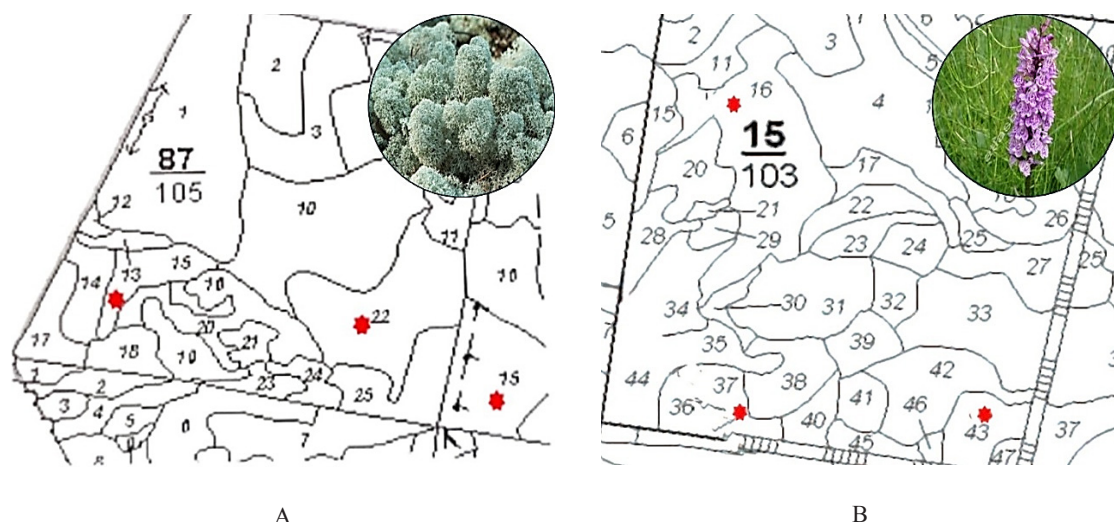
Economic importance: Fodder (animal feed), medicinal.

Conservation status: Included in the Red Data Book of Kazakhstan, belongs to Category 5. Sensitive to anthropogenic pressure (forest fires, logging, soil erosion). It can disappear quickly during ecosystem degradation; therefore, it is considered an important indicator species for assessing the purity of forest ecosystems.

Locations found in the territory of Kokshetau SNNP: Arykbalyk branch: Karauyltobe forestry – block 1, plot 2; block 4, plot 13; block 6, plot 3; block 7, plot 13; block 9, plots 10, 12, 14; block 10, plot 19; block 16, plot 6; block 19, plot 9. Leykovskoye forestry – block 46, plot 29; block 95, plot 5. Torgay forestry – block 30, plot 7; block 31, plot 24; block 32, plot 18. Tomen'gi Burlyk forestry – block 87, plots 13, 15, 22; block 91, plot 3; block 96, plot 22. Zerendi branch: Zerendi forestry – block 4, plot 10; block 9, plot 24; block 11, plot 15; block 67, plot 2; block 68, plots 2, 3; block 75, plot 4; block 89, plots 3, 4, 7; block 120, plot 18. Zhylandy forestry – block 50, plots 34–37; block 62, plots 2–5, 8; block 88, plots 12, 13. Shalkar branch: Akan-Seri forestry – block 50, plot 31. Kostobe forestry – block 23, plot 18; block 48, plot 13.

Figure 2

Fragment of the growth site of *Cladonia rangiferina* (L.) F.H.Wigg. (A) and *Orchis fuchsii* Druce (B) (Tomen'gi Burlyk forestry – block 87, plots 13, 15, 22; Kostobe forestry – block 15, plots 16, 37, 43)



4. *Orchis fuchsii* Druce (Fig. 2).

A perennial rhizomatous plant belonging to the family *Orchidaceae*.

Geographical distribution: Widely distributed in the temperate zones of Europe and Asia. In Kazakhstan, it is found in the Northern and Eastern regions, the Kokshetau Highlands, Burabay SNNP, Karkaraly, as well as in forest-steppe and mountainous areas.

Ecology: Grows in meadows, forest edges, near marshes, and in places with moist and humus-rich soil. Hygrophyte, light-loving (photophilous), but also tolerant of slight shade.

Economic importance: Medicinal, ornamental.

Conservation status: Included in the Red Data Book of Kazakhstan, a rare species belonging to Category 3. Populations are very sensitive to anthropogenic impacts (draining of marshes, logging, recreational pressure, flower picking).

Locations found in the territory of Kokshetau SNNP: Arykbalyk branch: Karauyltobe forestry – block 9, plots 4, 12, 14; block 13, plots 2, 3, 7, 9, 11; block 14, plots 8, 15, 17; block 24, plot 25. Torgay forestry – block 10, plot 15. Tomen'gi Burlyk forestry – block 2, plot 24; block 89, plot 12. Zerendi branch: Zerendi forestry – block 54, plot 2;

block 55, plot 3; block 77, plot 6. Shalkar branch: Kostobe forestry – block 16, plot 29; block 15, plots 16, 37, 43. Ormandy Bulaq branch: Ormandy Bulaq forestry – block 28, plot 17.

5. *Adonis vernalis* L. (Fig. 3).

A perennial herbaceous plant belonging to the family *Ranunculaceae* Juss., which flowers in early spring.

Geographical distribution: A species typical of the steppe and forest-steppe zones of Eurasia. In Kazakhstan, it is distributed in the dry and semi-desert steppes of the West and North Kazakhstan, Akmola, Kostanay, and Pavlodar regions, as well as in the Kokshetau Highlands and the territory of the Kokshetau and Burabay SNNP.

Ecology: Grows in dry steppes with chernozem and dark chestnut soils, on open slopes, in sparse shrub communities, and at forest edges. Light-loving (photophilous), xeromesophyte.

Economic importance: Medicinal and ornamental.

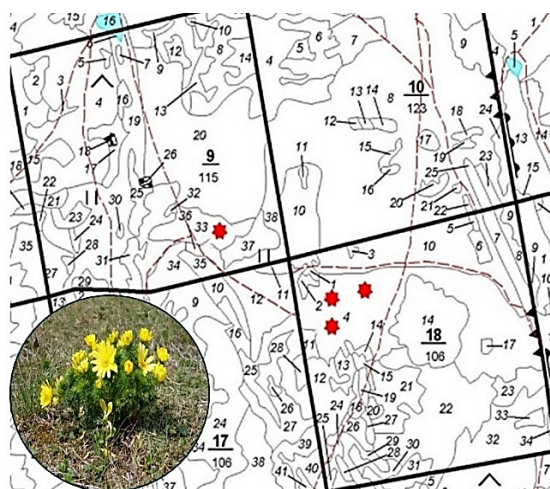
Conservation status: Included in the Red Data Book of Kazakhstan, a rare and endangered species of Category 3. The number of populations has been decreasing in recent decades, which is associated with livestock grazing, land plowing, haymaking, and high recreational load.

Locations found in the territory of Kokshetau SNNP: Arykbalyk branch: Leykovskoye forestry – block 5, plots 4, 7; block 12, plot 4; block 46, plot 27. Aiyrtau branch: Sh. Ualikhanov forestry – block 160, plots 4, 8, 18, 26. Zerendi branch: Gribnovskoye forestry – block 25, plot 16; block 31, plots 10, 26; block 46, plot 49. Zhylandy forestry – block 9, plot 11. Zerendi forestry – block 9, plot 33; block 18, plot 4. Shalkar branch: Akan-Seri forestry – block 32, plot 70. Ormandy Bulaq branch: Ormandy Bulaq forestry – block 28, plot 14; block 89, plot 9.

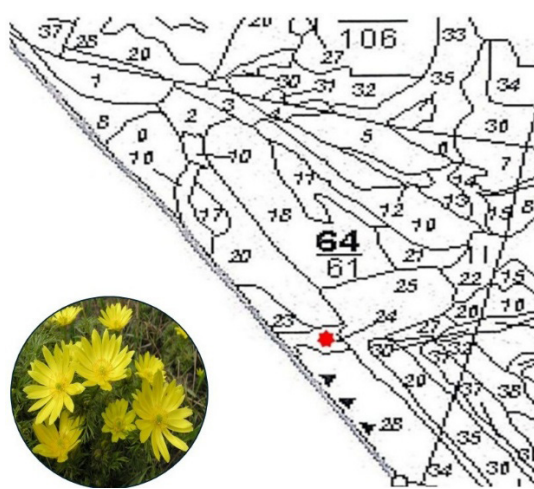
Figure 3

Fragment of the growth site of *Adonis vernalis* L. (A) and *Adonis wolgensis* Stev.

(B) (Zerendi forestry – block 9, plot 33; block 18, plot 4; Torgay forestry – block 64, plot 24)



A



B

6. *Adonis wolgensis* Stev. (Fig. 3).

An early-flowering perennial herbaceous plant belonging to the family *Ranunculaceae* Juss.

Geographical distribution: A species typical of the steppe and forest-steppe zones of Eurasia. Found in the Northern, Western, and Central regions of Kazakhstan, mostly in the steppe and forest-steppe belts of the Kostanay, Akmola, Pavlodar, and West Kazakhstan regions.

Ecology: Grows in fescue-feather grass and feather grass steppes, rarely at forest edges and for-

est glades. Light-loving (photophilous), mesoxerophyte.

Economic importance: Medicinal.

Conservation status: Included in the Red Data Book of Kazakhstan, a rare species belonging to Category 3.

Locations found in the territory of Kokshetau SNNP: Arykbalyk branch: Torgay forestry – block 58, plot 5; block 64, plot 24. Zerendi branch: Gribnovskoye forestry – block 143, plot 25.

7. *Nymphaea alba* L. (Fig. 4).

A perennial aquatic plant belonging to the family *Nymphaeaceae* Salisb.

Geographical distribution: Widely distributed in the temperate zone of Eurasia. In Kazakhstan, it is found in the Volga-Ural region, North Kazakhstan, Akmola, and Kostanay regions, in lakes and slow-flowing rivers. It is frequently encountered in the lakes of Kokshetau, Burabay, and Zerendi.

Ecology: Grows in still or slow-flowing, fresh, and slightly brackish waters. It feeds through a submerged rhizome. Hydrophyte, light-loving (photophilous).

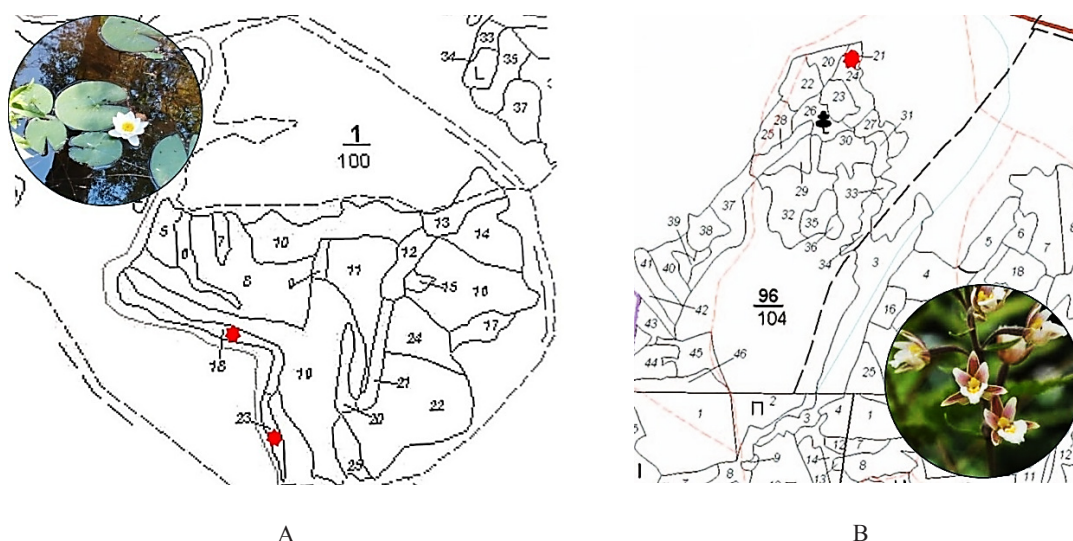
Economic importance: Technical (tanning) and food (source of starch).

Conservation status: A widespread species, but due to its rarity in Kazakhstan, it is included in the Red Data Book of Kazakhstan, belonging to Category 3. Populations suffer from changes in water levels, pollution of water bodies, and recreational pressure (boating, swimming).

Locations found in the territory of Kokshetau SNNP: Arykbalyk branch: Tomen'gi Burlyk forestry – block 1, plots 18, 23. Aiyrtau branch: Syrymbet-Tukti forestry – block 120, plot 64. Ormandy Bulaq branch: Ormandy Bulaq forestry – block 9, plot 9.

Figure 4

Fragment of the growth site of *Nymphaea alba* L. (A) and *Epipactis palustris* (L.) Crantz (B) (Tomen'gi Burlyk forestry – block 1, plots 18, 23; Ormandy Bulaq forestry – block 96, plot 21)



8. *Epipactis palustris* (L.) Crantz (Fig. 4).

A perennial plant belonging to the family *Orchidaceae* Lindl.

Geographical distribution: Covers most of Europe, the Caucasus, Central Asia, West and East Siberia, Western Europe, the Mediterranean region, the Balkan Peninsula, Asia Minor, and Dzungaria. It is distributed in the northern, eastern, and mountainous regions of Kazakhstan.

Ecology: Grows in wet marshy meadows, river valleys, and among moist forests and shrubs. This species is considered an indicator plant reflecting the stability of moist ecosystems. Hygrophyte.

Economic importance: Medicinal, ornamental.

Conservation status: Belongs to Category 4 according to the Red Data Book of Kazakhstan. The number of its populations is a cause for concern.

Locations found in the territory of Kokshetau SNNP: Ormandy Bulaq branch: Ormandy Bulaq forestry – block 96, plot 21. Aiyrtau branch: Sh. Ualikhanov forestry – block 45, plot 36; block 46, plot 26.

9. *Stipa pennata* L. (Fig. 5).

A perennial herbaceous plant belonging to the family *Poaceae*.

Geographical distribution: Distributed in Europe, Southern Siberia, and Central Asia. In Kazakhstan, it is found in steppe and forest-steppe zones, occurring especially frequently in Northern and Central Kazakhstan.

Ecology: A representative of dry steppe, fescue-feather grass, and feather grass steppe communities. Grows on chernozem and dark-chestnut soils, sometimes in slightly saline areas. Xerophyte.

Economic importance: Fodder (animal feed).

Conservation status: Category 3, a rare species according to the Red Data Book of Kazakhstan. European feather grass is an indicator species of the natural steppe ecosystem; therefore, its conservation is an important part of protecting steppe biocenoses.

Locations found in the territory of Kokshetau SNNP: Arykbalyk branch: Leykovskoye forest-

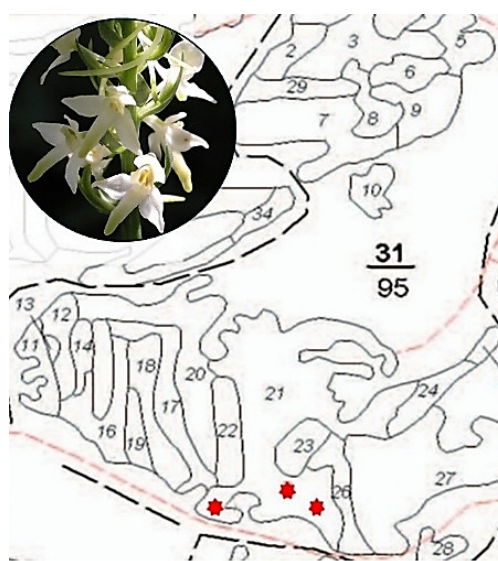
ry – block 57, plot 16. Zerendi branch: Zerendi forestry – block 10, plot 13; block 42, plot 32; block 44, plot 1; block 48, plot 17; block 56, plot 6; block 57, plots 7, 11; block 58, plots 13, 14; block 59, plots 11, 14. Shalkar branch: Shalkar forestry – block 43, plot 47. Ormandy Bulaq branch: Ormandy Bulaq forestry – block 21, plot 1.

Figure 5

Fragment of the growth site of *Stipa pennata* (A) and *Platanthera bifolia* (L.) Rich. (B) (Leykovskoye forestry – block 57, plot 16; Shalkar forestry – block 31, plot 21)



A



B

10. *Platanthera bifolia* (L.) Rich. (Fig. 5).

A perennial plant belonging to the family *Orchidaceae* Lindl.

Geographical distribution: The general distribution area covers the European part of Russia, the Caucasus, West and East Siberia, Western Europe, the Mediterranean region, the Balkan Peninsula, and Asia Minor. Within the territory of Kazakhstan, this species is recorded in the Tobol–Ishim region and the Altai mountain region.

Ecology: Grows in sparse forests, among shrubs, and in forest meadows. Mesophyte.

Economic importance: Medicinal, ornamental.

Conservation status: An insufficiently studied species belonging to Category 4 according to the Red Data Book of Kazakhstan.

Locations found in the territory of Kokshetau SNNP: Shalkar branch: Kostobe forestry – block 72, plot 6. Shalkar forestry – block 31, plot 21.

11. *Chimaphila umbellata* (Fig. 6).

A perennial plant belonging to the family *Ericaceae* Juss.

Geographical distribution: Covers the European part, West and East Siberia, the Far East, Scandinavia, Central Europe, Japan, and North America. Within the territory of Kazakhstan, it is found in the northern part of the Tobol–Ishim region, the Irtys region, and the Kokshetau region.

Ecology: This species is a component of coniferous and mixed forest ecosystems. Xeromesophyte.

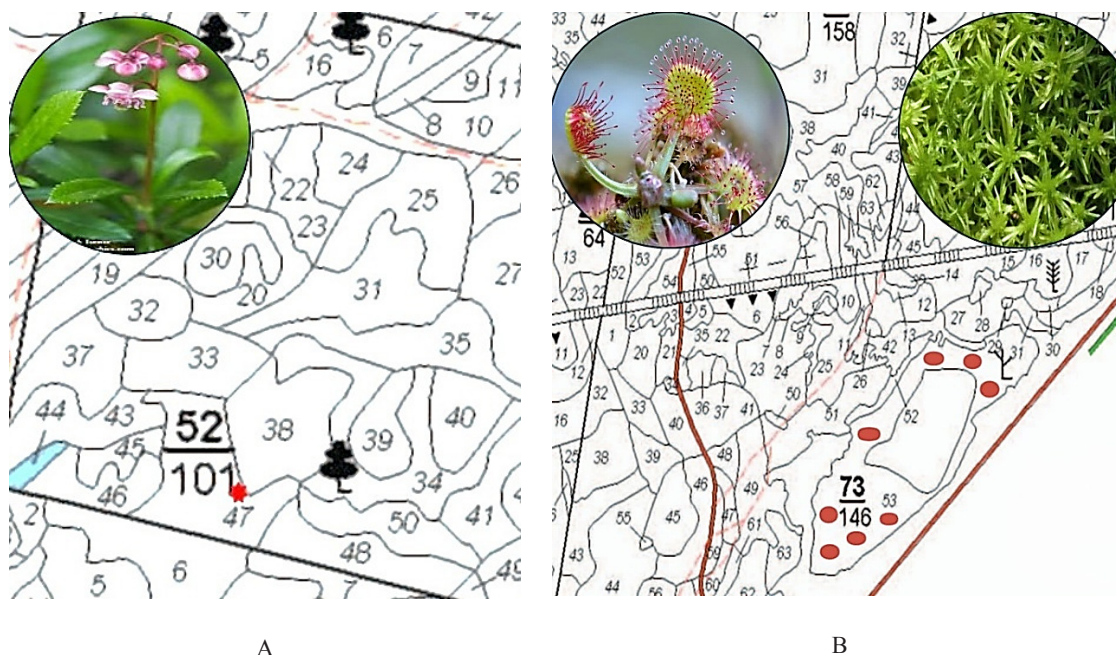
Economic importance: Medicinal.

Conservation status: Category 3 – a rare species according to the Red Data Book of Kazakhstan.

Locations found in the territory of Kokshetau SNNP: Ormandy Bulaq branch: Ormandy Bulaq forestry – block 91, plots 36, 38, 39, 40. Aiyrtau branch: Sh. Ualikhanov forestry – block 52, plot 47.

Figure 6

Fragment of the growth site of *Chimaphila umbellata* (A), *Drosera rotundifolia* (B) and *Sphagnum teres* (Schimp.) (C) (Sh. Ualikhanov forestry – block 52, plot 47; Shalkar branch: Kostobe forestry – block 73, plot 53)



12. *Drosera rotundifolia* (Fig. 6)
A perennial plant belonging to the family *Droseraceae* Salisb.

Geographical distribution: Widely distributed in Europe, the Caucasus, West and East Siberia, the Far East, Western Europe, Northern Mongolia, Japan, and North America. Within the territory of Kazakhstan, it is found in the Kokshetau region, the Mugalzars, and along the Torgay River.

Ecology: This species is an important component of moist ecosystems and participates in the process of peat formation. Hygrophyte.

Economic importance: Medicinal.

Conservation status: A rare species belonging to Category 4 according to the Red Data Book of Kazakhstan.

Locations found in the territory of Kokshetau SNNP: Shalkar branch: Kostobe forestry – block 73, plot 53.

13. *Sphagnum teres* (Schimp.) (Fig. 6).

A moss belonging to the family *Sphagnaceae*.

Geographical distribution: Distributed in Scandinavia, Central and Eastern Europe, Siberia, the Far East, Canada, and the northern parts of the USA; found in the northern regions of Kazakhstan.

Ecology: Widely distributed in marshy ecosystems

and is one of the primary peat-forming organisms. Hygrophyte.

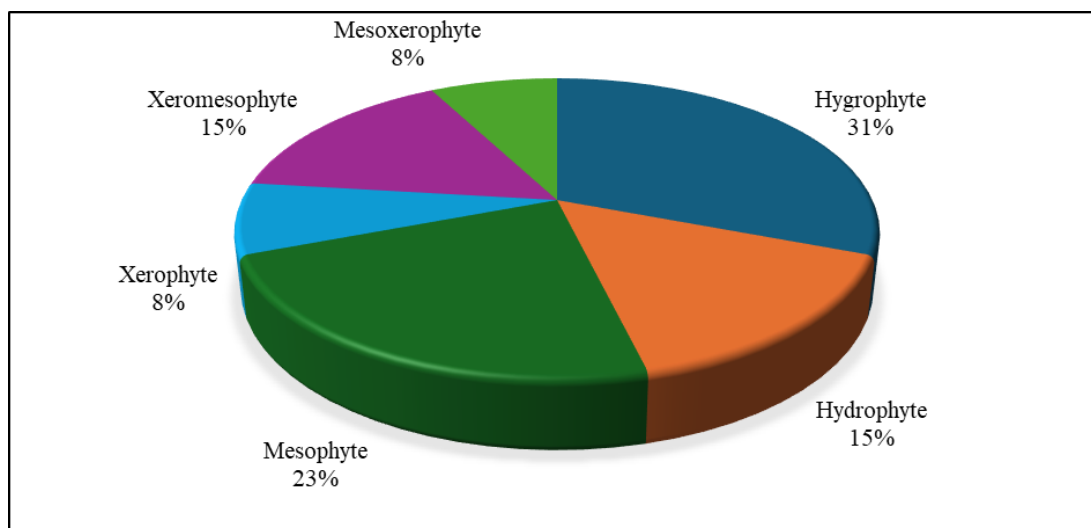
Economic importance: Medicinal.

Conservation status: A rare species belonging to Category 3 according to the Red Data Book of Kazakhstan.

Locations found in the territory of Kokshetau SNNP: Shalkar branch: Kostobe forestry – block 73, plot 53.

When we analyzed the plant species included in the Red Data Book identified within the territory of Kokshetau SNNP based on their ecological characteristics, the majority of the studied species belong to the hygrophyte, xeromesophyte, and mesophyte ecological groups. This indicates that marsh, forest, and steppe ecosystems develop together within the territory of Kokshetau SNNP. Since forest ecosystems are rare and create a unique microclimate, they provide conditions for the preservation of rare species.

Among the research subjects, the largest shares are held by hygrophytes (31%) and mesophytes (23%). Together, these two groups account for more than half of the flora (54%). This indicates that the moisture level of the region is sufficient or high, as well as the predominance of wetlands or meadow lands (Figure 7).

Figure 7*Ecological groups of rare plants growing within the territory of Kokshetau SNNP*

Hydrophytes (15%) and xeromesophytes (15%) occur in equal proportions. The fact that hydrophytes account for 15% confirms the presence of water bodies (lakes, rivers) in the region. The presence of xeromesophytes indicates that there are also transition zones slightly adapted to drought. Xerophytes (8%) and mesoxerophytes (8%) are represented in the smallest amounts. This proves that the share of dry, desert, or steppe landscapes in the studied area is very low.

According to the diagram results, this flora can be described as “moisture-loving.” The vast majority of plants (approximately 69%: hygrophytes, hydrophytes, and mesophytes) are adapted to growing in conditions of high and medium humidity (Figure 7).

When analyzing the species by their Red Data Book status, 8 of the studied plants belong to Category III, 3 belong to Category IV, and 2 belong to Category V. Although the populations of these plants are not currently facing an immediate threat of extinction, the narrowness of their distribution

areas and their sensitivity to anthropogenic factors require special protection. The classification of the studied species as rare categories increases their biological and ecological importance. Most of them are characteristic of specific biocenoses—forest-steppe, meadow, or marsh ecosystems—and play an important role in maintaining ecosystem stability. Furthermore, some species represent the floral uniqueness of the region as relict or endemic elements.

In this regard, constant monitoring of the distribution of these species, tracking population dynamics, protecting habitats, and limiting anthropogenic load should be priority directions for scientifically based nature conservation measures.

All of the studied species have economically important medicinal properties; some are used as animal feed or for ornamental purposes.

We conducted an analysis of the similarity of the rare plant flora of the 5 branches of Kokshetau SNNP (Zerendi, Ormandy Bulaq, Shalkar, Aiyrtau, Arykbalyk) (Table 1).

Table 1*The Red Data Book plant species by branches of “Kokshetau” SNNP*

№	Plant Names	Branches				
		Zerendi	Ormandy Bulaq	Shalkar	Aiyrtau	Arykbalyk
1	<i>Pulsatilla flavescens</i> (Zucc.) Juz.	1	1	1	1	1
2	<i>Pulsatilla patens</i> (L.) Mill.	1	0	1	0	1
3	<i>Adonis vernalis</i> L.	1	1	1	1	1
4	<i>Adonis wolgensis</i> Stev.	1	0	0	0	1

№	Plant Names	Branches				
		Zerendi	Ormandy Bulaq	Shalkar	Aiyrtau	Arykbalyk
5	<i>Cladonia rangiferina</i> (L.) F.H.Wigg.	1	0	1	0	1
6	<i>Orchis fuchsii</i> Druce	1	1	1	0	1
7	<i>Stipa pennata</i> L.	1	1	1	0	1
8	<i>Nymphaea alba</i> L.	0	1	0	1	1
9	<i>Platanthera bifolia</i> (L.) Rich.	0	0	1	0	0
10	<i>Epipactis palustris</i> (L.) Crantz	0	1	0	1	0
11	<i>Chimaphila umbellata</i> (L.) W.P.C.Barton	0	1	0	1	0
12	<i>Drosera rotundifolia</i> L.	0	0	1	0	0
13	<i>Sphagnum teres</i> (Schimp.) Ångstr.	0	0	1	0	0

Note: 1 – species is present in the branch; 0 – species is absent in the branch.

Pulsatilla flavescens and *Adonis vernalis* L. species are found in all 5 branches. The wide distribution of these species indicates their high ecological flexibility and the similarity of the natural and climatic conditions of the region.

A similar pattern was shown by the species *Orchis fuchsii* and *Stipa pennata*. They were found in 4 branches. These species represent the commonality of forest-steppe and meadow ecosystems.

As a result of analyzing the similarity of the flora of the branches using the Jaccard coefficient, several patterns were identified:

The highest similarity was observed between the Zerendi and Arykbalyk branches ($J = 0,75$). This indicates that the species composition of these two areas is very close, meaning their ecological conditions and the nature of their vegetation cover are similar. Furthermore, high similarity was also identified between the Zerendi and Shalkar branches ($J = 0,67$), as well as between the Shalkar and Arykbalyk branches ($J = 0,67$). This suggests that the flora of these three branches belongs to a uniform forest-steppe complex.

A medium level of similarity was recorded between the Ormandy Bulaq and Aiyrtau branches ($J = 0,56$), as well as between the Ormandy Bulaq and Arykbalyk branches ($J = 0,50$). This means that there are common species in their flora, but certain differences occur in their ecological conditions.

A low similarity index was determined between the Shalkar and Aiyrtau branches ($J = 0,17$). This indicates that differences predominate in the species composition of these two areas and reflects the distinctness of their natural conditions.

In general, according to the analysis results, the Zerendi, Shalkar, and Arykbalyk branches form one

floral group. Meanwhile, the flora of Aiyrtau appears relatively isolated. The Ormandy Bulaq branch occupies an intermediate position, characterized by its own unique features while maintaining common traits with some branches.

Conclusion

The conducted research aimed to determine the distribution, ecological characteristics, and conservation status of rare plant species within the territory of the Kokshetau State National Natural Park. During the study, plants belonging to the families *Ranunculaceae*, *Orchidaceae*, *Ericaceae*, *Droseraceae*, *Sphagnaceae*, and others were examined.

According to the results, the majority of the studied species belong to Category III rare plants included in the Red Data Book of Kazakhstan. This indicates that their populations are highly sensitive to anthropogenic impacts.

The studied plants are mainly distributed in forest-steppe, marsh, and meadow ecosystems. Based on the results of the ecological analysis, it was determined that the majority of species belong to the hygrophite, mesophyte, and xeromesophyte groups. In particular, the occurrence of species with peat-forming and bioindicator significance in the floristic composition of marsh ecosystems characterizes the relative stability of the natural environment.

The territory of Kokshetau SNNP is an important natural reserve for the preservation of rare plant species. However, factors such as recreational load, forestry activities, livestock grazing, and changes in the hydrological regime may pose a threat to plant populations.

Therefore, in order to preserve the studied plant species, it is necessary to conduct regular monitoring of natural populations, reduce anthropogenic pressure, and strengthen protection measures in specially protected areas.

Conflict of Interest

No conflict of interest was declared.

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Memeshov S.K. – Formal analysis, Methodology, Investigation, Validation.

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