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Abstract: This article presents the analysis of the allocation of important plant areas (IPA), which urgently identifies the most valuable sites for protecting plant objects. The study is based on a comprehensive inventory of the species composition of plants in the flora of the Western Karatau Ridge and the Mangyshlak Peninsula (arid regions)- key sites Akmysh, Samal, and Kogez, considered standard and the best preserved with natural vegetation cover. The flora of these critical sites was analysed using a combination of field surveys, herbarium studies, and a literature review. The results revealed a rich biodiversity, with 104 species from 82 genera and 33 families. Most species belong to 9 families, making up 60.6% of the total taxa. By the nature of life forms, perennial herbaceous plants dominate in all key sites (30 species, 50.0%). The eco-phylogenetic spectrum showed that a significant share of the flora of the studied IPAs is made up of xerophytes (21 species, 35%) and xeromesophytes (9 species, 15%); desert and mountain-steppe species prevail (53.0%). Rare, endangered and Red Book species account for 10-21.3% of those growing in the region. Regarding economic value, fodder, ornamental, honey, medicinal and food species dominate. The Shannon, Simpson, and Jaccard indices assessed alpha-beta and gamma diversity. The index showed that biodiversity in the Samal and Kogez sites is higher and more evenly distributed compared to the Akmysh site. The Whittaker, Harrison and Cody indices confirm significant differences in the species composition between the sites. In light of these compelling results, a clear and urgent call to action is proposed to allocate these areas to the IPA category, a crucial step towards ensuring the long-term existence of natural biocenoses.

Keywords: biodiversity; biogeography; arid land; important plant areas; phytosociology; plant communities

1. Introduction

The study of biodiversity in mountain and arid regions is important in modern botany, ecology and biogeography. Mountain ecosystems cover about 27% of the Earth's land surface and serve as habitat for many species of higher vascular plants, including many endemic and rare species [1]. Mountain and arid regions are crucial in maintaining global biodiversity, regulating hydrological cycles and climate processes, and providing vital ecosystem services such as protection against soil erosion and desertification [2,3].

Due to their isolation and diverse ecological niches, mountain and arid ecosystems are often sites of significant plant biodiversity and endemism. Intensive speciation occurs in these regions, and many species have adapted to the unique conditions of mountain landscapes, including extreme climatic conditions and specific soils [4]. However, mountain and arid ecosystems are also vulnerable to climate change and anthropogenic impacts, making their study and conservation a priority for scientists and conservation organisations [5].

One unique mountain that includes arid ecological systems is the Western Karatau, located in the Mangistau region of Kazakhstan, which is considered an extra-arid zone and is one of the unique

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ecosystems of our antler. These mountains are characterised by various climatic and geographical conditions, contributing to the development of unique plant communities. The study of such ecosystems is essential for understanding their ecological role and developing strategies for preserving biodiversity in the context of a changing climate and anthropogenic impact [6]. Western Karatau is an essential object of research for several reasons. Its isolated location and diverse ecological niches create conditions for developing endemic plant species. The region is home to both widespread species and rare and endemic plants, some of which are endangered. The floristic diversity of the Western Karatau includes about 1,200 plant species representing different ecosystems, from steppes and semi-deserts to forest and meadow communities. Including such a large number of species in the study allows us to obtain a comprehensive picture of the region's structure and dynamics of plant communities. Several main ecological groups of plants can be distinguished among the region's plant communities. In the arid steppes and semi-deserts, xerophytes dominate – plants adapted to dry conditions, such as *Artemisia lerchiana* Weber ex Stechm. and *Salsola arbuscula* Pall. On more humid and shady slopes, mesophytes in the mountainous areas prefer moderately humid conditions, including *Hedysarum turkestanicum* Regel & Schmalh., and *Geranium transversale* (Kar. & Kir.) Vved. In river floodplains and temporary watercourses, hygrophytes that require constant or periodic moisture are widespread, such as Carex physodes M. Bieb. and Juncus articulatus L. Such a diversity of ecological groups reflects the adaptation of plants to various microclimatic conditions and contributes to the overall stability of the ecosystem. It is important to note that many of these species are of significant ecological and economic importance, which makes their conservation a priority for local and international conservation programs [7]. Of the total number of species, about 150 are endemic to this region, emphasising its high scientific and conservation value [8].

One essential tool for assessing mountain systems' biodiversity is using various biodiversity indices in certain important plant areas. The most widely used indices are alpha diversity and beta diversity. Alpha diversity characterises the species richness and evenness of species distribution within a particular site or community. High alpha diversity indicates high species richness and even species distribution in the community [9]. Beta diversity measures differences in species composition between different communities or sites and reflects the degree of ecological or geographic isolation [10].

The Shannon index (H') and the Simpson index (D) also help assess the species richness and uniformity of species distribution in the community. The Shannon index considers the number of species and their relative abundance, allowing for a more complete picture of the biodiversity structure. High values of the Shannon index indicate high biodiversity and uniform distribution of species [11]. The Simpson index, on the other hand, focuses on the dominance of individual species in the community. Low values of the Simpson index indicate high biodiversity since the dominance of one species decreases [12]. These indices are actively used in ecological and genetic studies to compare the biodiversity of different ecosystems and assess changes in the community under the influence of various factors in Kazakhstan [13]. Using biodiversity indices allows ecological-botanical and genetic studies to be more quantitatively substantiated and comparative, which is especially important in developing strategies for conserving and studying biodiversity [14–17]. The Jaccard Index is used to compare biodiversity between different communities or sites, which evaluates the degree of similarity and difference between sets of species. The Jaccard Index is defined as the ratio of common species to the total number of species in two compared communities. This index is often used to study beta diversity and allows one to estimate the degree of overlap of species compositions between different ecosystems [18]. The use of various computer programs significantly facilitates the collection, analysis and interpretation of data. Statistical programs such as R and SPSS allow for complex statistical analyses, including regression and cluster analysis, which help identify various significant characteristics—using the PAST 4.03 program allowed for a comprehensive analysis of biological diversity using modern statistical methods, which contributed to a deep understanding of the structure and dynamics of the studied ecosystems.

The study of plant biodiversity is an essential aspect of ecology, especially in the context of unique and sparsely populated regions. The Western Karatau mountain system is a unique ecosystem in Kazakhstan's Mangistau region. These mountains are characterised by various climatic and geographical conditions, which contribute to developing unique plant communities [19]. This study often uses the important plant areas (IPA) method. This method involves the identification and detailed analysis of the most significant sites regarding biodiversity. Field studies were carried out in each of the selected gorges, including an inventory of species, an assessment of their abundance and condition, and the collection of samples for further analysis. In each site, various parameters were analysed, including alpha diversity, beta diversity, species richness, plant density and their spatial distribution. Information on identifying IPA (Important Plant Areas) provides a context for understanding global biodiversity conservation initiatives. The Plantlife initiative, an international non-governmental organisation, and its IPA identification project are essential to conserving rare plants and their habitats [20].

The essential plant areas method is used in various countries worldwide to assess and conserve plant biodiversity. For example, in Great Britain and South Africa, this method is used to monitor the status of rare species and their habitats, which helps develop effective measures for their protection [21]. In South America and Australia, the IPA method has also proven effective in studying ecosystems with a high degree of endemism [22]. The experience of these countries shows that using the IPA method improves understanding of the spatial distribution of vegetation and the development of specific strategies for its conservation in mountain systems. The first version of the IPA designation guide, released in 2001, has become essential for applying the IPA designation criteria in Europe.

In Kazakhstan, studies were conducted in the North Tien Shan botanical-geographical subprovince [23–25], where more than 11 key areas with high floristic, macrobiotic and phylogenetic diversity were identified. However, studies on the identification of IPA have not been conducted for other territories of Kazakhstan, including the study region. Therefore, these studies and the identification of IPA emphasise the importance of accounting for and conserving botanical diversity, especially in small areas, to ensure the long-term existence of unique species and communities in different regions worldwide. The IPA system provides an information basis for assessing the botanical value, the effectiveness of existing protected natural areas (PAs) and the possibility of their expansion [26]. As a network of specialists, Planta Europa is engaged in conserving rare plants in Europe and their habitats [27]. The tasks of Planta Europa include compiling the List of IPA in Europe based on the application of criteria familiar to all countries. The IPA selection criteria consider various aspects such as floristic richness, the presence of rare and endemic species listed in the Red Books, and the importance of the evolution and conservation of the biosphere. Rare and threatened plant communities (habitats) are also considered [28].

This work emphasises the relevance of the problem of preserving biodiversity in desert ecosystems of the Mangystau region in conditions of intensive economic activity, recreational load and pasture impact. The diversity of species of plants in the Mangystau region is one of the main significant elements of the southwestern part of the flora of Kazakhstan. Thus, this study aims to expand knowledge about Kazakhstan's floristic diversity of mountain ecosystems and contribute to developing effective measures for their protection and sustainable use.

Particular attention is paid to determining species diversity in small areas where rare, vulnerable and endemic species grow. Important plant areas (IPA) are considered a tool for this purpose. From a botanical point of view, they are the most valuable areas of natural vegetation selected based on standardised criteria. It is important to note that, despite their botanical value, IPAs are not specially protected natural areas (SPNA), and their boundaries are not fixed by law [29,30].

The selection of the territory of the Mangystau region as an object for the allocation of IPA is explained by a complex of factors, including climate change, mudflows and increasing anthropogenic load on natural ecosystems, especially in the territory intensively used for pastures [31]. The mountainous territories of the region are distinguished by high floristic diversity, the presence of endemic and relict species, and a reduction in the ranges of rare species and plant communities. It

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should be noted that these territories and objects are still insufficiently studied and lack appropriate protection. This emphasises the need for more detailed research and the allocation of IPA to manage and protect botanical diversity in the Mangystau region effectively. Such research and the allocation of IPA can serve as an essential tool for solving the problems associated with nature conservation in the context of a changing climate and anthropogenic impact. They can also contribute to developing more effective strategies for protecting and managing natural resources in the region.

The presented information provides the context for conducting research and identifying IPA in the Gornomangyshlak district of the Mangistau region. This region is located southwest of the Buzachinsky district, bordering the East and Central Mangyshlak districts to the east and has a maritime border to the west and south. It should be noted that earlier surveys were conducted to find important plant areas of the Mangistau region, where significant information was accumulated on the location of rare, endemic, and endangered plant species and the best-preserved regions of plant communities. As a result of these studies, the Catalogue of Rare and Endangered Plant Species (Red Book) of the Mangistau Region [32,33].

This publication is considered a logical continuation of previous studies and aims to develop a system of protected natural objects in the Gornomangyshlak District. Possible areas include conserving areas with natural vegetation, which provides for large populations of rare and endemic, economically valuable species, preservation of reference communities, monitoring of biodiversity of the main functional groups of plants and creating a database on plant biodiversity and valuable habitats. IPAs are also testing grounds for managing biodiversity and ecosystem functions of various components of the region's biogeocenoses. These efforts are aimed at more effective conservation and management of biodiversity in this region.

The choice of the Mangyshlak Peninsula mountainous territory as the optimal model for considering the issues of IPA allocation is due to two main reasons that allow for the practical adaptation and development of methodological approaches specifically on this territory. The first of these is that Mangyshlak is a small, well-defined, and, at the same time, quite diverse territory with unique natural conditions. The peninsula is located within two large botanical and geographical areas, namely the North and South Turan provinces. There are various types of relief here, such as plateaus, eolian sandy plains, arid lowlands, cliffs, closed endorheic basins, and coastal accumulative plains. This ensures a diversity of ecotopes, an essential factor for studying biodiversity. The second reason is the sufficient botanical study of the territory, both in floristic and geobotanical terms. Also, the territory is located in extra-arid conditions, which creates an increased threat to the conservation of plant biological diversity.

This allows for a more in-depth and detailed analysis, considering the existing body of knowledge about this area's flora and plant communities. This work aims to describe the composition of the flora of the Western Karatau Gorges as key areas with preserved natural flora to determine the need for protection and inclusion in the IPA. This study aims to study the plant biodiversity of various gorges of the Western Karatau in detail. The work considers quantitative and qualitative vegetation characteristics and analyses the factors influencing its distribution and dynamics. Particular attention is paid to identifying rare and endemic species and assessing their current status and threats. It is expected that the results of this study will contribute to a deeper understanding of the processes determining the diversity of plant communities and will help in the development of conservation strategies.

2. Materials and Methods

2.1. Study Area

The territory of the Mangistau region includes the Buzachi and Mangyshlak (Mangystau) peninsulas, the western half of the Ustyurt plateau, and the Western Karatau gorges [34]. The flora of the Mangistau region belongs to the typical desert type [35]. It has 675 species from 69 families and 300 genera [36]. Most species belong to Chenopodiaceae, Asteraceae, Brassicaceae, Poaceae, and Fabaceae [37].

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The study area is mountainous and is an arid zone. Western Karatau is part of a mountain system located in the western part of the Mangistau region. The Karatau Mountains extend from the southwest to the northeast, including several ridges and plateaus. The height of the mountains is relatively low compared to other mountain systems in Kazakhstan.

The climate in the Western Karatau region is typically continental and arid. Summers are hot and dry, with minimal precipitation, while winters can be cold but usually without significant snowfall. Under such conditions, the flora and fauna are adapted to extreme temperature fluctuations and water shortages. Western Karatau can be characterised as continental, with pronounced seasonal fluctuations in temperature and precipitation. Winters are cold and severe, with temperatures falling below -20°C, while summers are hot, reaching +40°C. The average annual rainfall varies from 100 to 200 mm, making the region arid. Such climatic conditions create unique conditions for forming specific plant communities adapted to extreme temperatures and limited moisture [38].

The Western Karatau Mountains are a narrow elevation, stretched in a sublatitudinal direction, with a total length of no more than 45 km. Average absolute marks in this area fluctuate within 300-400 m, and the highest points reach 532 m. Characterising the Western Karatau ridges, a well-defined levelling surface consisting of stable metamorphic rocks, including Permian and Triassic shales and siltstones with interlayers of conglomerates and limestones should be noted. At the foot of the ridge, Jurassic variegated deposits are visible. A unique feature of the Western Karatau Mountains is the gorges caused by the close occurrence of groundwater and the presence of self-flowing springs of fresh water, contributing to the formation of a rich vegetation cover.

In botanical and geographical terms, this territory is part of the Tyubkaragan-Gornomangyshlak district, characterised by the predominance of wormwood deserts in the composition of the vegetation cover. Despite some similarities, the species composition of the flora of each of these regions has its originality. The flora of Western Karatau is diverse and includes many species adapted to the dry climate. Endemic and rare plant species can be found here, which makes the region an essential object for botanical research.

2.2. Plant Materials

The primary material is presented based on the results of field studies conducted in 2023 within the Western Karatau Mountains, where eight essential plant areas were identified, of which three main ones are considered in this paper - Akmysh, Samal, Kogez (Figure 1), the best preserved with natural vegetation cover, which includes a large proportion of populations of rare and endemic, economically valuable species. We also studied the following herbarium collections: LE, MW, TK, MHA, SVER, KUZ, ALTB, AA, NUR, KG, KSPI, NS, NSK, MOSP, ORIS, PPIU [39,40].

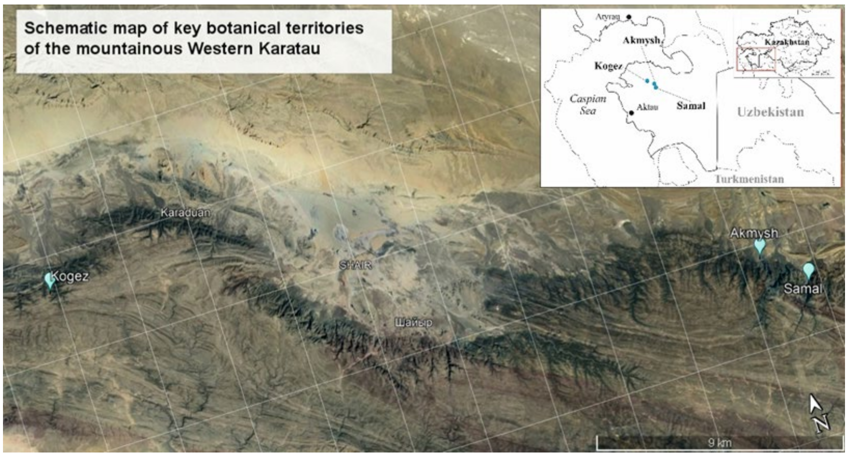

Figure 1. Map-scheme of the IPA of the Western Karatau mountains.

An IPA passport was developed for each site using a methodology adapted from the European Important Botanical Areas Information System (EUNIS) and based on Anderson's guide to selecting

IPA in Europe [41]. The methodology was also adapted for the Altai-Sayan region (Russia) [42] and the Northern Tien Shan botanical-geographical subprovince [43].

For the strategy of preserving the most critical ecosystems, the approaches proposed at the European public organisation Planta Europa conference in 1995 in Gisre (France) were used as the most important from a botanical point of view in the guidelines for identifying vital botanical territories. Important Plant Areas, IPA [44,45].

The Samal, Akmysh, and Kogez gorges are characterised by their relatively deep canyon-like shape, considerable length, and abundant water resources—a rarity for the desert zone. These features make the gorges floristically rich.

In the process of determining the IPA, it should be noted that in the relationship between the Samal, Akmysh and Kogez gorges as potential candidates for inclusion in the general monitoring network, the determining criterion is the presence of rare species and species requiring special monitoring on the Mangyshlak Peninsula and the abundance of species in the flora, especially taking into account the importance of woody and semi-woody species in the desert flora of Mangyshlak [46].

In this case, a multi-level selection system based on a top-down approach was used when selecting IPA. The system includes the following levels: Each level has its criterion corresponding to the specifics of the territory under study.

2.3. Floristic Analysis

In this work, widely accepted traditional methods of botanical research were used, such as floristic, eco-geographical, and geobotanical. Expeditionary research of the objects was carried out using the conventional route survey method, covering the most diverse biotopes (landscape-ecological conditions) and their characteristic phytochromes. Descriptions at points in a slight ellipse were carried out 1-2 km from each other. The study of the IPA vegetation cover was carried out using the traditional method of geobotanical research, including the description of plant communities. Particular attention was paid to analysing vegetation's spatial distribution (structure), its relationship with other landscape components (relief, soils, etc.), and the assessment of species diversity and the state of vegetation. The taxa authors are cited per the rules adopted in the summary of S. K. Cherepanov and S. A. Abdulina [47,48]. Identification of the collected herbarium material was carried out using fundamental summaries: "Flora of Kazakhstan" [49–51] and "Illustrated Guide to Plants of Kazakhstan" [52]. The nomenclature of each taxon was carried out by "Plants of the World Online" [53]. Each species' conservation status was determined per the Red Book of Kazakhstan [54].

2.4. Statistical Processing of Biological Diversity Determination

The following methods were used in this work: Calculation of alpha diversity by Shannon index (H') measures diversity considering both species richness (total number of species) and the evenness of their distribution. Simpson index (D) estimates the probability that two randomly selected individuals belong to the same species [55].

Beta diversity Bray-Curtis similarity was calculated to compare diversity between different communities. Cluster analysis for Hierarchical clustering was used to visualise the similarity between samples. In this case, merging methods such as single and average linkage were used.

The main statistical methods for identifying biodiversity were performed using the PAST program. The PAST (Paleontological Statistics) program, version 4.03, was used to analyse biodiversity in this study. PAST is a powerful tool for performing various statistical analyses, including biodiversity analysis [56]. Data were collected from different sites in the study area, and a species inventory was conducted for each sample. Using PAST 4.03 allowed for a comprehensive analysis of biodiversity using modern statistical methods, which contributed to a deep understanding of the structure and dynamics of the studied ecosystems.

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3. Results

3.1. Floristic Analysis

The results of the floristic analysis are presented for three main key areas:

IPA Akmysh is located in the valley of the gorge of the Akmysh River, Western Karatau Range, in the Tupkaragan District of the Mangystau Region. Akmysh is a stream with a small grove along the banks, fed by mountain springs, sometimes turning into a small trellis and sometimes drying up due to a dry spring. Coordinates: 44°13′42.0″N; 51°58′34.6″E. Height - 275 m above sea level. Plot area - 1300x70 (30) m.

The site occupies a winding gorge with steep slopes stretching about 1.3 km and 30-70 m wide. The entrance to the gorge is vast but narrows to 20-30 m towards the bottom. The communities proposed for selection occupy a gentle slope, the lower part and the bottom of the gorge. The substrate is represented by stony-gravelly soil; sandy and clayey soils appear at the foot of the ridge. The Akmysh botanical site is a typical mountain-desert vegetation characteristic of the middle and lower parts of the gorges of the Western Karatau mountain range. The vegetation cover is slightly disturbed, and the floristic diversity of the communities is pretty well represented, including both low-grass ephemeroids (Poa bulbosa L.) and representatives of savannah tall grasses (Verbascum songaricum Schrenk, Polygonum aviculare L.). Weeds are found in small quantities in the communities. Species included in the Red Book of Kazakhstan are found in this area.

In quantitative terms, the described area is dominated by tree-shrub species, such as Crataegus ambigua C.A. Mey. ex A.K. Becker, Rhamnus sintenisii Rech. fil., Caragana grandiflora (M. Bieb.) DC., Atraphaxis replicata Lam., and the subshrub Convolvulus fruticosus Pall. Sparse Gurgan-wormwood forests with petrophytic perennial herbs grow on the slopes: Centaurea squarrosa Willd., Cousinia onopordioides Ledeb., Lagochilus acutilobus (Ledeb.) Fisch. & C.A. Mey., Verbascum songaricum Schrenk; characteristic cereals are: Poa bulbosa L., Stipa caspia K. Koch. The bottom of the gorge near the spring is covered with thickets of mesophytes, represented by Carex diluta M. Bieb., Mentha longifolia (L.) Huds., Galium humifusum M. Bieb., Marrubium vulgare L., Prangos odontalgica (Pall.) Herrnst. & Heyn, Crambe edentula Fisch. & C.A. Mey. ex Korsh., Veronica amoena M. Bieb., Polygonum aviculare L., Phragmites australis (Cav.) Trin. ex Steud., Erodium cicutarium (L.) L'Hér., Plantago lanceolata L., and occasionally, a small amount of Ziziphora tenuior L. is found. Thickets of Achnatherum splendens (Trin.) Nevski grows on saline soils near the spring.

Compliance with criteria: Criterion A (iii) – Presence of rare species included in the Red Book of Kazakhstan, such as Crataegus ambigua C. A. Mey., Crambe edentula Fisch., as well as Artemisia gurganica (Krasch.) Filat., Rubus caesius L., listed in the Catalogue of Rare and Endangered Plant Species of Mangistau. The criterion overall is the high diversity of species of plants characteristic of mountain desert territories represented in this vital area.

The area is subject to anthropogenic impact and grazing, as evidenced by some weed species: Centaurea squarrosa Willd., Cichorium intybus L., Cynodon dactylon (L.) Pers., Peganum harmala L., Ceratocarpus utriculosus Bluket ex Krylov. The vegetation cover and habitats in the described area are excellent and stable. There is no protection by territorial protection. It is necessary to take it under observation, conduct monitoring studies to track the condition of its vegetation cover and ensure the required security.

IPA Samal is located in the Samal mountain gorge of the Western Karatau ridge, Mangistau district, Mangistau region. The site coordinates are 44 ° 12′56.8 "N; 51 ° 59′37.0″ E. The height is 274 m above sea level, and its area is 2500 x 100 meters. Mountain-semi-desert communities predominate in this area. The floristic diversity of the Samal Gorge includes 55 species of vascular plants. The endemic species Ephedra lomatolepis Schrenk and three Red Book species participate in forming the vegetation cover: Malus sieversii (Ledeb.) M. Roem, Crataegus ambigua C. A. Mey., and Crambe edentula Fisch.

The site is a winding gorge located on the slope of a ridge, three kilometres from the Akmysh gorge. A rich stream with fresh water flows along the bottom of the gorge for about a kilometre. The communities proposed for allocation occupy the slopes, lower part, and bottom of the gorge. The

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soils are brown, clayey, and very stony. The site is dominated by a hawthorn-forb community (Crataegus ambigua—Herba varia).

Floristic diversity on the rocky peaks of the gorge is widespread in wormwood, where two species predominate - Artemisia gurganica (Krasch.) Filatova and A. lerchiana L., as well as the shrub Atraphaxis replicata Lam. Among the herbs, there is Ephedra aurantiaca Takht. & Pachom., Tanacetum santolina C. Winkl., Teucrium polium L., Alhagi pseudalhagi (M.Bieb.) Desv., Echinops ritro L. On the mountain slopes between the rocks and along the banks of the flowing spring river grow single trees - Elaeagnus angustifolia L., Ulmus pumila L. Thickets of Crataegus ambigua C.A.Mey. ex A.K.Becker, and in places Rubus caesius L. can be found. In deeply incised gorges with rocky slopes, individual bushes of Rhamnus sintenisii Rech. Fil. On the bottoms of gorges, near springs, thickets of herbaceous perennials are common – Mentha longifolia (L.) Huds., Phragmites australis (Cav.) Trin. ex Steud., Plantago lanceolata L., Carex diluta M. Bieb., are significantly widespread – Nepeta cataria L., Lagochilus acutilobus (Ledeb.) Fisch. & C.A. Mey., Trachomitum scabrum (Russanov) Pobed., Acanthophyllum pungens (Bunge) Boiss., Meristotropis triphylla (Fisch. & C.A. Mey.) Fisch. & C.A. Mey. On the lower part of the slopes, cereals are rarely found: Stipa caspia K. Koch, S. caucasica Schmalh., Agropyron fragile (Roth) P. Candargy, and Poa bulbosa L.

The site's botanical value is evident because several well-known species have been recorded, and plants in the Red Book grow there. The undisturbed shrub thickets of the steep slope serve as a refuge for preserving these rare species. The water regime, including groundwater, streams, springs, and temporary watercourses, also protects this biodiversity.

Meets criteria: A (iii) – Presence of rare species listed in the Red Book of Kazakhstan, such as Malus sieversii (Ledeb.) M.Roem., Crataegus ambigua C.A. Mey., and Crambe edentula Fisch., as well as Artemisia gurganica (Krasch.) Filat., Rubus caesius L., included in the catalogue of rare and endangered plant species of Mangistau; overall high species diversity of plants characteristic of mountain desert territories represented in this vital area; the habitat is occupied by little disturbed communities of low-mountain vegetation, including shrub thickets with hawthorn, which is natural undisturbed communities due to their inaccessibility.

The territory is partially used for grazing, but the central part of the vegetation cover is assessed as background with spots of a low degree of unresolved state. The low density of settlements contributes to the preservation of beautifully flowering ornamental and medicinal species. The condition of rare species in the Samal Gorge section is stable, but recreational load and grazing of livestock pose a threat. The degree of transformation is estimated at 20-25%. Part of the site requires a complete ban on grazing. There is no protection by territorial security. Measures are needed to regulate and limit the recreational load. To ensure the preservation of rare and endemic plant species, it is proposed that a specially protected territory in the form of important plant areas (IPA Samal Gorge) be established. This will allow for effective measures to regulate recreational activity, introduce a ban on grazing and establish the necessary restrictions for the sustainable conservation of vegetation and its unique species.

IPA Kogez is located in a mountain rocky gorge of the Western Karatau ridge in the Mangistau district, Mangistau region. Its coordinates are 44°17′17.0″N and 51°39′49.0″E, and the altitude reaches 253 meters above sea level. The total area of the site is 2000x50-100 m. The habitat is characterised by a gentle slope with a small cluster of shrubs, Caragana grandiflora (Bieb.) DC., and wormwood (Artemisia austriaca Jacq., Artemisia santolina Schrenk).

This site is an example of a typical mountain desert. It includes thickets of xerophytic shrubs, in particular Crataegus ambigua C.A.Mey. ex A.K.Becker, as well as xerophytic perennial herbaceous communities (25%) and herbaceous communities on dry soils (15%). In the shrubby undergrowth of Caragana grandiflora (M. Bieb.) DC., in addition to wormwood, Chenopodium album L., Teucrium polium L., and Nepeta cataria L. predominate. Among the annual species of the families Apiaceae, Caryophyllaceae, and Cruciferae are Scandix stellata Banks & Sol., Stellaria media (L.) Vill., Chorispora tenella (Pall.) DC., Camelina sylvestris Wallr. Such species represent the group of ephemerals as Arnebia decumbens (Vent.) Coss. & Kralik, Koelpinia linearis Pall. Of the ephemeroids, the following are noted: Carex diluta M. Bieb., Carex songorica Kar. & Kir., Leontice

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incerta Pall., Rheum tataricum L., Allium sp. Annual and perennial herbs include Alyssum dasycarpum Stephan ex Willd., Lepidium ruderale L., Agropyron fragile (Roth) P. Candargy, Mentha longifolia (L.) Huds., Plantago lanceolata L., Galium aparine L., etc. The total projective cover is 60-65%.

Meets criteria: A (iii) – the presence of 5 rare species listed in the Red Book of Kazakhstan: Crataegus ambigua C. A. Mey., Crambe edentula Fisch., Salix alba L., Armeniaca vulgaris Lam. and Malus sieversii (Ledeb.) M. Roem, as well as five species included in the catalogue of rare and endangered plant species of Mangistau: Artemisia gurganica (Krasch.) Filat., Rubus caesius L., Rhamnus sintenisii Rech., Capparis herbaceae Sp., Teucrium polium L.; High floristic diversity of the critical botanical territory is demonstrated by 58 species of higher plants found in the IPA and 4 Red Book plant species growing on it; habitat occupied by little disturbed communities of low-mountain vegetation. Shrub thickets with hawthorn represent natural, undisturbed communities due to their inaccessibility.

The condition of rare species is stable. The main threats are recreational load, mudflows, and livestock grazing. The degree of transformation is estimated at 20-25%, and signs of abnormal development have not been identified. Restrictions on livestock grazing are necessary. There is no protection by territorial protection, and regulations and restrictions on recreational load are essential. Protection of rare and endemic species can be ensured by establishing a specially protected area in the form of IPA Kogez.

Thus, the floristic analysis of three important plant areas (Akmysh, Samal and Kogez) in the Mangistau region of the Western Karatau ridge revealed significant floristic diversity and the presence of rare plant species listed in the Red Book of Kazakhstan. Each site represents unique ecosystems with different vegetation types and specific habitat conditions. The Akmysh, Samal, and Kogez sites have high floristic diversity and are important objects for the conservation of biodiversity in the region. Measures are needed to protect and sustainably manage these territories to preserve their unique ecosystems and rare plant species for future generations. The general list of plant species is presented in Table S1.

3.2. Taxonomic Analysis

Taxonomic analysis of the floras of the three critical areas under study showed that 60 species of vascular plants belonging to 53 genera and 26 families grow in the Akmysh Gorge. At the same time, 55 species representing 49 genera and 23 families were identified in the Samal Gorge IPA, and 58 from 51 genera and 25 families in the Kogez Gorge IPA.

In the research process to assess the similarity of floras of different IPAs, the Jaccard coefficient was used, which is the ratio of the number of similar taxa for two communities to their sum for each list minus the number of common species. As we can see from the materials in Table 1, the Jaccard coefficient for the Akmysh - Samal and Akmysh - Kogez sites is almost the same, with relatively low values of 0.27-0.28. And vice versa, - Samal - Kogez increases almost twice to 0.56 (56%) due to the similarity of relief and soil-hydrological conditions.

Table 1. Evaluation of the similarity of the studied IPA floras using the Jaccard coefficient.

IPA		Coefficient Kj
1	Akmysh Samal	0.28
2	Akmysh Kogez	0.27
3	Samal Kogez	0.56

Most species belong to the families Asteraceae, Fabaceae, Brassicaceae, Poaceae, Polygonaceae, Chenopodiaceae, Caryophyllaceae, Lamiaceae, and Rosaceae. Species from these nine leading families comprise 60.6% of the total.

Analysis of the nature of life forms in all IPAs revealed the following features (Table 2): herbaceous perennials dominate the plots – 30 species (50.0% of the total number of species); in second place are herbaceous annuals and biennials – 14 species (23.6%), in third place are trees and shrubs – 5 species each (18.2%), subshrubs and dwarf subshrubs are represented by ten species (16.6%), and subshrubs – 1 species (1.8%).

Table 2. IPA life form analysis.

Biomorphs	IPA					
	Samal		Akmysh		Kogez	
	Number of species	%	Number of species	%	Number of species	%
Tree	5	9,1	3	5,0	6	10,3
Bush	6	10,9	7	11,6	6	10,3
Subshrub	3	5,4	3	5,0	4	6,9
Subshrub 2	2	3,6	2	3,3	3	5,2
Perennials	27	49,1	31	51,6%	25	43,1
Biennials	1	1,8	3	5,0	2	3,4
Annuals	11	20,0	11	18,3	12	20,6
Total:	**55**	**100,0**	**60**	**100,0**	**58**	**100,0**

Ecological analysis showed that a significant proportion of the flora of the studied IPAs consists of xerophytes (21 species or 35%) and xeromesophytes (9 species or 15%), which is associated with the severe aridity of the climate of Mangistau.

The spectrum of ecological-phylogenetic groups confirmed the predominance of desert and mountain-steppe species, which constitute the majority (53%). A significant share falls to desert-steppe species (36.7%). Meadow-steppe species make up 8% of the total flora. Water-coastal species occupy 5.3% of the total flora.

Weed species were identified, constituting 34.4% of the total flora composition of the territory's studied areas. This indicates high anthropogenic load and cattle grazing in all studied IPAs.

Of the plants of the natural flora of Mangystau, seven species are listed in the Red Book of Kazakhstan, and 40 species are included in the "Catalog of Rare and Endangered Plant Species of the Mangystau Region (Red Book). From this list, the results of our study showed that the following species from the Red Book are noted in all IPAs: Crataegus ambigua C.A. Mey., Crambe edentula Fisch., as well as Artemisia gurganica (Krasch.) Filat., Rubus caesius L., listed in the catalogue of rare and endangered plant species of Mangystau. Only in the Kogez area is the presence of the Red Book species Salix alba L. and Armeniaca vulgaris Lam. and Rhamnus sintenisii Rech., Capparis herbaceae Sp., Teucrium polium L., included in the Red Book of Mangystau, noted. In addition, the presence of a species listed in the Red Book, Malus sieversii (Ledeb.) M. Roem is noted in the Kogez and Samal areas.

There is no territorial protection in all areas. The condition of rare species in the region is stable, but recreational load and livestock grazing pose a threat. To ensure the preservation of rare and endemic plant species, it is necessary to establish a specially protected area in the form of important plant areas in the Samal area.

3.3. Analysis of Biological Diversity

The results on various indices of biological diversity were obtained. The index of alpha biodiversity is presented in Table 3. These data show different biodiversity indices for three places: Samal, Akmysh and Kogez. Akmysh has the highest number of species (59), followed by Kogez (57) and Samal (55). Samal has the highest number of individuals (2145), followed by Akmysh (1730) and Kogez (1584).

Table 3. Alpha diversity index.

Title	Samal	Akmysh	Kogez
Taxa_S	55	59	57
Individuals	2145	1730	1584
Dominance_D	0,02255	0,02544	0,02299
Simpson_1-D	0,9774	0,9746	0,977
Shannon_H	3,888	3,86	3,885
Evenness_e^H/S	0,8874	0,8044	0,854
Brillouin	3,821	3,777	3,799
Menhinick	1,188	1,418	1,432
Margalef	7,04	7,779	7,601
Equitability_J	0,9702	0,9466	0,961
Fisher_alpha	10,29	11,82	11,57
Berger-Parker	0,04662	0,0578	0,04735
Chao-1	55	59	57

The dominance indices are low, indicating no dominance of individual species, with slightly higher dominance at Akmysh (0.02544) compared to Samal (0.02255) and Kogez (0.02299). The Simpson and Shannon indices indicate high diversity at all sites. Samal has the highest evenness of species distribution (0.8874), followed by Kogez (0.854) and Akmysh (0.8044). The Brillouin, Menhinick and Margalef indices also show high diversity, with the highest values at Akmysh. The Fisher alpha index confirms higher diversity at Akmysh (11.82). The Berger-Parker index indicates higher dominance at Akmysh (0.0578). The actual species number estimate (Chao-1) agrees with the number of taxa for all sites. Overall, all three sites show high biodiversity, with slight differences in evenness and species dominance, with Akmysh showing slightly greater diversity.

The graphs in Figure 2 show the differences in biodiversity between the three locations, Samal, Akmysh, and Kogez, using the Shannon and Simpson indices. Shannon H Plot: The Shannon Index measures species diversity by considering the number of species and their relative abundance. The Shannon Index values are Samal: 3.888, Akmysh: 3.86, and Kogez: 3.885. The graph shows that the biodiversity in Samal and Kogez is almost the same and slightly higher than in Akmysh. This means that the species in Samal and Kogez are more evenly distributed than in Akmysh. Simpson H Plot: The Simpson Index measures the probability that two randomly selected individuals belong to different species. The higher the value, the greater the biodiversity. Simpson index values: Samal: 0.9774 Akmysh: 0.9746 Kogez: 0.9770

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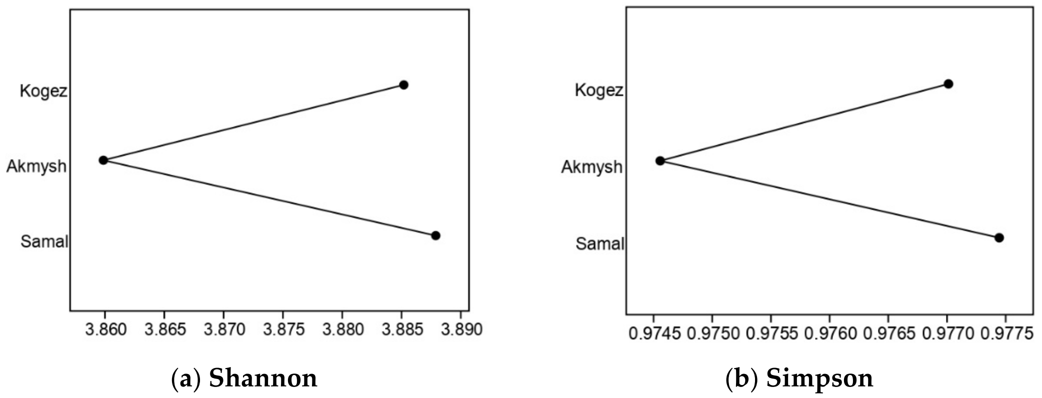

Figure 2. Differences in biodiversity between three sites, Samal, Akmysh and Kogez, using the (**a**) Shannon and (**b**) Simpson indices.

The graph shows that biodiversity in Samal and Kogez is again slightly higher than in Akmysh, with almost identical values for Samal and Kogez. This confirms the high biodiversity in these locations, where species are less likely to dominate. Both indices show that biodiversity in Samal and Kogez is higher than in Akmysh. This may indicate more stable and evenly distributed ecosystems in Samal and Kogez. While all three locations show high diversity, the slight differences indicate advantages of Samal and Kogez in terms of even distribution of species and overall ecological stability. The diversity profile for three locations was also analysed: Samal (black), Akmysh (red), and Kogez (blue). The results are presented in Figure 3.

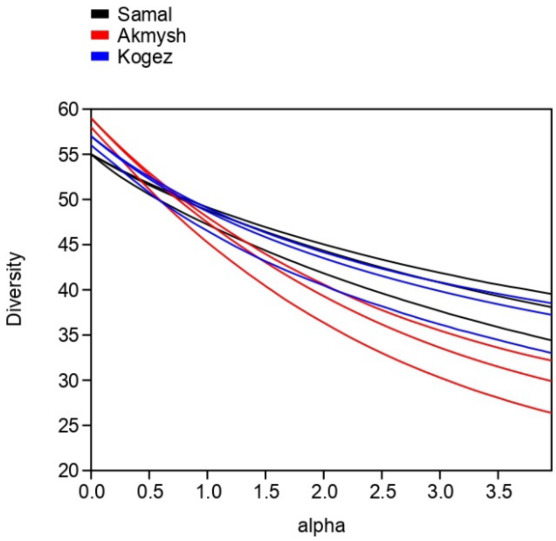

Figure 3. Diversity profiles for three sites: Samal (black), Akmysh (red) and Kogez (blue).

This graph displays the diversity profiles for three sites: Samal (black), Akmysh (red), and Kogez (blue). The x-axis is alpha (α) values, and the y-axis is diversity. Diversity: A biodiversity measure considering the number of species and their relative abundance. Alpha (α) parameter that modifies the level of emphasis on the evenness of species distribution. Low α values give more weight to rare species, while high α values give more weight to dominant species. Interpretation: Samal (black): The Samal curve is higher than the Akmysh curve and roughly at the same level as the Kogez curve, indicating higher diversity, especially at low α values. This suggests that Samal has relatively more rare species compared to Akmysh. The Akmysh curve lies lower than the others, indicating lower diversity than Samal and Kogez. This suggests that species in Akmysh are less evenly distributed, with more dominant species. The Kogez curve is close to the Samal curve, especially at medium and high α values. This indicates high diversity and even distribution of species in Kogez, almost at the level of Samal. The diversity profile plot shows that Samal and Kogez have higher biodiversity and

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more even species distribution than Akmysh. Akmysh has lower biodiversity and more pronounced dominance of individual species. These data support the conclusions based on Shannon and Simpson indices about more stable and diverse ecosystems in Samal and Kogez compared to Akmysh. Beta diversity analysis was also conducted; the results are presented in Table 4.

Table 4. Beta diversities.

Global beta diversities	
Whittaker:	0,80702
Harrison:	0,40351
Cody:	65
Routledge:	0,20829
Wilson-Shmida:	1,1404
Mourelle:	0,57018
Harrison 2:	0,37288
Williams:	0,42718

The results show different indices of global beta diversity. Beta diversity measures the differences in biodiversity between different places or habitats. Here is a brief explanation of each index: Whittaker: 0.80702. This index measures the overall diversity in a region relative to the average local diversity. A value of 0.80702 indicates significant differences in biodiversity between places. Harrison: 0.40351. The Harrison index measures the proportion of species unique to different locations. A value of 0.40351 indicates moderate differences in biodiversity. Cody: 65. The Cody index considers changes in species composition along a gradient. A value of 65 indicates significant changes in species along an environmental gradient. Routledge: 0.20829. The Routledge index measures species composition differences by considering rare species. A value of 0.20829 indicates moderate differences, taking into account rare species. Wilson-Shmida: 1.1404. The Wilson-Schmid index measures changes in species composition along environmental gradients. A value of 1.1404 indicates significant changes in species along the gradients. Mourelle: 0.57018. The Mourelle index measures species diversity, taking into account their occurrence. A value of 0.57018 indicates moderate differences in species composition. Harrison 2: 0.37288. The second version of the Harrison index also measures the uniqueness of species among locations. A value of 0.37288 indicates moderate differences in biodiversity. Williams: 0.42718. The Williams index measures biodiversity differences among locations while considering overall species composition. The value of 0.42718 indicates moderate differences in species composition. These indices show significant differences in biodiversity between the different sites, with different indices emphasising different aspects of these differences. The Whittaker, Cody, and Wilson-Schmid indices show substantial changes in species composition, while the Harrison, Rowledge, Murelle, and Williams indices indicate moderate differences. This highlights the importance of using multiple indices to understand beta diversity in the study region comprehensively. Therefore, a pairwise comparison analysis of beta diversity was conducted. The results are presented in Table 4. The pairwise comparison table shows the beta diversity between three sites: Samal, Akmysh, and Kogez.

Table 4. Pairwise comparisons.

	Samal	Akmysh	Kogez
Samal	0	0,5614	0,28571
Akmysh	0,5614	0	0,56897
Kogez	0,28571	0,56897	0

The values in the table represent measures of species composition differences between pairs of locations. The higher the value, the more significant the difference in biodiversity between the two locations. Samal vs. Akmysh: 0.5614. The value 0.5614 indicates a significant difference in species composition between Samal and Akmysh. Samal vs. Kogez: 0.28571. The value 0.28571 indicates a moderate difference in species composition between Samal and Kogez. Akmysh vs. Kogez: 0.56897. The value 0.56897 indicates a significant difference in species composition between Akmysh and Kogez. Samal vs. Akmysh: The value 0.5614 shows that biodiversity significantly differs between Samal and Akmysh. This may indicate differences in environmental conditions or the influence of human activities. Samal and Kogez: The value of 0.28571 indicates a moderate difference in biodiversity between Samal and Kogez. This suggests these two sites have a more similar species composition than the Samal-Akmysh pair. Akmysh and Kogez: The value of 0.56897 shows that the biodiversity in Akmysh and Kogez also differs significantly. This confirms that Akmysh has significant differences in species composition with both other sites. The pairwise comparison table highlights the considerable differences in biodiversity between Akmysh and the other two sites (Samal and Kogez). At the same time, the differences between Samal and Kogez are less pronounced, which may indicate similar ecological conditions or management practices in these sites. The species richness (diversity) in one quadrat was analysed. The results are presented in Table 5.

Table 5. Quadrat richness.

Original data set:	**Standard devs:**	
Observed S:	103	
Chao 2:	145,56	15,5405
Jackknife 1:	141	12,0554
Jackknife 2:	156	NA
Bootstrap:	120,778	NA
Bootstrap replicates means:	Standard devs:	
Chao 2:	99,3015	28,3718
Jackknife 1:	104,557	26,4671
Jackknife 2:	110,738	31,1317
Bootstrap:	120,778	20,2299

The table provides data on the species richness (diversity) in a single quadrat and the standard deviations for the different richness estimates. Main data set: Observed S: 103. This is the number of species in the quadrat surveyed—Chao 2: 145.56 (standard deviation: 15.5405). The Chao 2 estimate considers rare species and assumes that the number of species in the quadrat is 145.56. The standard deviation indicates the variation in this estimate—jackknife 1: 141 (standard deviation: 12.0554). The first Jackknife estimate assumes that the number of species in the quadrat is 141. The standard deviation also indicates the degree of variation. Jackknife 2: 156 (standard deviation: NA). The second Jackknife estimate suggests that the number of species in the square is 156. No standard deviation data are available—bootstrap: 120,778 (standard deviation: NA). The Bootstrap estimate suggests that the number of species in the square is 120,778. No standard deviation data are available. Bootstrap replicates, mean values: Chao 2: 99.3015 (standard deviation: 28.3718). The mean Chao 2 value for Bootstrap replicates is 99.3015. The standard deviation indicates considerable variation—jackknife 1: 104.557 (standard deviation: 26.4671). The mean Jackknife 1 value for Bootstrap replicates is 104.557. The standard deviation also indicates considerable variation. Jackknife 2: 110.738 (standard deviation: 31.1317). The average of Jackknife 2 for Bootstrap replicates is 110.738. The standard deviation indicates high variation—bootstrap: 120.778 (standard deviation: 20.2299). The average of Bootstrap for Bootstrap replicates is 120.778. The standard deviation indicates moderate variation.

Estimates of species richness (diversity) in a quadrat vary depending on the method used. The observed number of species is 103. The forecast from Chao 2, Jackknife 1, and Jackknife 2 suggest that

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the number of species may be higher, up to 156. The Bootstrap estimate gives a more conservative estimate of about 120,778 species. Bootstrap replicates show considerable variation in estimates, indicating uncertainty in the precise forecast of valid species richness. These data highlight the importance of using various methods to obtain a more accurate estimate of biodiversity in a study area.

3. Discussion

The research results show high species biodiversity in the essential plant areas (IPAs) of Akmysh, Samal, and Kogez, which is confirmed by the presence of many rare and endangered species. These territories deserve to be included in the general list of IPAs both on the scale of Kazakhstan and in the international context.

Research conducted by Ivanov and Petrov (2020) shows that the floristic diversity of the western Karatau includes about 1200 plant species, of which about 150 are endemic to the region. Our data confirm the high degree of endemism and rarity of species in critical sites. Compared with their results, our data show that 60 species of vascular plants grow in the Akmysh gorges, 55 in the Samal gorges, and 58 in the Kogez gorges. This highlights the importance of detailed studies and identifying specific critical sites for biodiversity conservation [57].

Different biodiversity assessment methods, such as Shannon, Simpson and Jaccard indices, provided a comprehensive picture of biodiversity in the study areas. Shannon and Simpson indices showed a more uniform distribution of species in Samal and Kogez compared to Akmysh, which is consistent with the studies of Zomer et al. (2006), where the use of multi-index biodiversity assessment showed high efficiency in identifying IPA [58].

All three IPAs show significant impacts from anthropogenic factors, such as recreational load and grazing. This is confirmed by the high content of weed species (34.4% of the total flora), indicating a high degree of anthropogenic load. Similar results were obtained by Bogdanov (2016) in a study of steppe and semi-desert ecosystems in Western Kazakhstan, where anthropogenic impact was also noted as one of the main factors affecting biodiversity [59,60].

The results of the conducted studies confirm the high species biodiversity in the identified IPAs Akmysh, Samal and Kogez, with the prevalence of perennial grasses and the presence of rare and endangered species, which allows us to conclude that the identified vital areas fully meet all three criteria and deserve to be included in the general list of IPAs on the scale of Europe, the CIS and Kazakhstan. They represent valuable objects for biodiversity conservation and should be considered when planning various activities, including recreation, plant introduction and economic use.

Based on the taxonomic analysis of the flora in the critical area of the Akmysh Gorge, 60 species of vascular plants belonging to 53 genera and 26 families grow; 55 species representing 49 genera and 23 families were identified in the IPA of the Samal Gorge and 58 species from 51 genera and 25 families in the Kogez gorge. The Jaccard coefficient calculated for assessing the similarity of floras of different IPAs has a relatively low value of 0.27-0.28 for the Akmysh - Samal and Akmysh - Kogez sections. At the same time, the Samal - Kogez IPA increases twofold - to 0.56, which is associated with their geomorphological and soil-hydrological identity.

One hundred four species from 82 genera and 33 families grow in three critical areas of Akmysh, Samal and Kogez. The predominant number of species (60.6% of the total) belong to nine families: Asteraceae, Fabaceae, Brassicaceae, Poaceae, Polygonaceae Chenopodiaceae, Caryophyllaceae, Lamiaceae, Rosaceae. Among the life forms in all IPAs, herbaceous perennials dominate – 30 species (50.0%); in second place are herbaceous annuals and biennials – 14 species (23.6%); in third place are trees and shrubs – 5 species each (18.2%). Subshrubs and subshrubs are represented by ten species (16.6%), dwarf shrubs – only one species (1.8%). In the ecological spectrum, xerophytes (21 species or 35%) and xeromesophytes (9 species or 15%) occupy a significant share of the flora. Among the ecological-phylogenetic groups, desert and mountain-steppe species predominate (53%) and desert-steppe species - 36.7%. No more than 8% belong to the meadow-steppe group, and 5.3% to the water-coastal group of the total flora. There are quite a lot of weeds - 34.4%.

Of the rare, endangered and Red Book species, 10 - 21.3% of those growing in the region were identified. *Crataegus ambigua* C.A. Mey., *Crambe edentula* Fisch., *Artemisia gurganica* (Krasch.) Filat., *Rubus caesius* L., included in the catalogue of rare and endangered plant species of Mangistau, are found in all IPAs. Only in the Kogez gorge was the presence of the Red Book species *Salix alba* L. and *Armeniaca vulgaris* Lam. and *Rhamnus sintenisii* Rech., *Capparis herbaceae* Sp., *Teucrium polium* L., included in the Red Book of Mangistau, revealed. Also, in the Kogez and Samal areas, the Red Book species *Malus sieversii* (Ledeb.) M. Roem.

It has been established that all areas are vulnerable due to a whole range of factors: location, intensive use in agriculture, increased anthropogenic load, etc. The most effective way to preserve rare plants is to maintain their natural populations. The allocation of the above areas to the category of critical botanical territories allows us to hope for the long-term existence of natural biocenoses without catastrophic changes. It is also essential to consider these areas with a high concentration of rare significant species when planning possible recreational and economic activities. Given the vulnerability of all three areas, it is proposed to use geographic data as an alternative or supplement when choosing new IPAs or specially protected natural areas.

5. Conclusions

Biodiversity analysis for the important plant areas Akmysh, Samal and Kogez in the Mangistau region showed high species diversity and the presence of rare and endangered plant species, making these areas important for conservation and monitoring. Shannon and Simpson's indices indicate a more even species distribution and high biodiversity in Samal and Kogez compared to Akmysh. Pairwise comparisons showed significant differences in species composition between Akmysh and the other two sites, while Samal and Kogez have more similar species composition. This may be due to differences in environmental conditions and anthropogenic impact.

Estimates of species richness (diversity) in one quadrat vary depending on the method used. The observed number of species is 103. Various assessment methods (Chao 2, Jackknife, and Bootstrap) indicate a possible number of species between 120 and 156. Based on the research, it is proposed to allocate these areas to the important plant areas category to ensure the long-term existence of natural biocenoses and the conservation of rare plant species. Regulating recreational load and limiting grazing are also recommended to minimise anthropogenic impact and maintain ecosystem stability.

Based on the research results, allocating the Akmysh, Samal, and Kogez areas to the essential plant areas category is recommended to ensure the long-term existence of natural biocenoses and the conservation of rare plant species. This will allow for the establishment of a protection regime, the regulation of recreational load, and the limitation of grazing, which are necessary measures to maintain ecosystem stability.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org, Table S1: Floristic spectrum of the important plant areas.

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