







Flora of the gorges Merke, Sandyk, Shaisandyk in the western part of Kyrgyz Alatau, a natural border between Kyrgyzstan and Kazakhstan

Zhailybayeva Take Muratovna^{1*} , Shalabayev Karatai Iskakovich¹ , Maimatayeva Assiya Duisengaliyeva¹ , Mombayeva Bekzat Kunsaliyeva² , Atraubaeva Roza Nurakhmetovna¹ , Beketova Aigul¹ 

1. NJSC Abai Kazakh National Pedagogical University, Almaty City, Kazybek bi 30, 050040, Kazakhstan
2. M. H. Dulati Taraz Regional University, Suleimanova Avenue 7, 080000, Taraz, Kazakhstan

* Corresponding author's E-mail: Gosha_take@mail.ru

ABSTRACT

The relevance of the article lies in monitoring the state of the natural mountain vegetation of the gorges of Merke, Sandyk, Shaisandyk and Araltobe as a natural zoning of the main changes in vegetation cover, in compiling classification schemes for the analysis of vegetation cover. In mountainous areas, local, isolated, floral complexes are formed, which are represented by alpine and subalpine meadows. The study of the composition and structure of the vegetation cover of individual regions is of great importance for establishing floral connections between different botanical and geographical regions. An episodic study of the flora and vegetation of the Merken district has been conducted by scientists in the last few years. There was a deterioration of vegetation in the western part of the Kyrgyz Alatau. Therefore, the purpose of this research was to study various groups of plants in this region, which will allow knowing the general development of flora, to outline the main stages of its formation. The main stages of the study were based on field expeditionary research, using route-reconnaissance and semi-stationary methods, data from scientific literature, herbarium material of their own collection and other colleagues. To analyse correlations in vegetation dynamics between the regions of the gorges of Merke, Sandyk, Shaisandyk and Araltobe, methods of mathematical statistics on the coefficient of floristic generality and graphical representation of materials were used. Since for many years there have been problems with studying the state of the floral composition of the gorges Merke, Sandyk and Shaisandyk, Araltobe, the results of the research aimed at taking inventory of the floral diversity of the zapodnaya part of the Kyrgyz ridge. During the analysis of plants of the studied area, 835 species belonging to 78 families and 336 families were identified.

Keywords: Plants, General species, Systematics, Flora, Merken district, Zhambyl region, Kirghiz ridge.

Article type: Research Article.

INTRODUCTION

In the south of Kyrgyzstan there is a mighty mountain range – the Kyrgyz Alatau. This is the western part of the Northern Tien Shan with an absolute height of 4315 m. Historically, the ridge was formed from ancient metaphorical rocks of granite, sandstone and limestone with conglomerates. The valley of the Kyrgyz Alatau is formed from the gentle Merke River, which originates in the mountainous Kokol Island, the Shaisandyk and Sandyk mountains, Araltobe. The Merke Gorge is rich in caves, mountain valleys, ridges and passes, more than a dozen peaks over 4000 m high, together with the valley of Aspara, the peaks of which are covered with snow until the beginning of June. While in the valleys at an altitude of 1800-2000 m above sea level, the snow cover reaches 20 cm, in the highlands, in some years: 40-50 cm of snow. In the west, towards the northern slopes of the Kyrgyz Alatau, the Kumbel and Zhalpaktash rivers, the Sandyk plateau is located, which in its central part becomes wider,

vegetation is sparse, trees and shrubs predominate. The region is poor in woodlands, locally there is a tree-like juniper. On the northern slopes, the predominant part of vegetation is alpine and subalpine meadows, on the southern – dry steppes, steppes and shrubby grasslands. Such domestic specialists have been studying the ecological and geographical characteristics of this region over the past three years (Nelina 2005; Muzylev *et al.* 2019; Terekhov *et al.* 2019; Utebekova *et al.* 2019; Zhang *et al.* 2020; Gulnara *et al.* 2020; Nelina *et al.* 2022). The flora of the Zhambyl region of the Merken district has more than 3 thousand species: legumes, Rosaceae, desert, steppe, meadow-steppe, subalpine, alpine and glacial belts are characteristic. The basis for the zoning of a mountainous territory is floristic research, which is carried out within the framework of any botanical and geographical work, since the state and species diversity of plants are a reliable and stable indicator of the variability of the microclimate, including its global change (Aghajani *et al.* 2023). For our research, the relevance has a comprehensive analysis of flora within individual natural-territorial units, assessment of plant life forms and their systematic groups. In this context, the analysis of the composition and assessment of the flora of the Sandyk, Shaisandyk, Araltobe and Merke gorges is a high priority for establishing floral links between the regions. Studies of Western European scientific literature (Rui *et al.* 2019; Tojibaev *et al.* 2020; Nowak *et al.* 2020) allowed getting an idea that the high-altitude location of the Kyrgyz Alatau is a split mountain-glacial relief, which determines the location of vegetation at an altitude of more than 2600 m. The steppe zone extends for 900 m up above sea level, at an altitude of 1600 m. There are fine-woody cereals, at an average altitude (up to 2800 m). The mountains are covered with a variety of grasses, a large number of shrubs and juniper elfin. Only in a small area of the Shaisandyk gorge spruce forests prevail, extending to the upper border, juniper elfin trees are rarely preserved. Height from 2600 to 3700 m is surrounded by subalpine, alpine meadows, juniper elfin. Subalpine meadows are famous for their diverse grasses, multicolours. However, since at such an altitude there is not enough oxygen, precipitation, and a large amount of scorching sun and strong wind, all the diversity of Alpine meadows burns out. Only such herbs common in mountainous areas as Edelweiss, Targyl, Lapchatka, wormwood are preserved, since they are the most hardy in such a climate. Over 3700 m there is no vegetation, as glaciers and rock mainly prevail there, snow leaves the peaks for a short time during summer periods. Merken district of Zhambyl region has a lot of mountain ranges and intermountain basins separated by gorges. The study of the territory has been laborious for a long time, so the vegetation is poorly studied. The inventory of the floristic diversity of the western part of the Kyrgyz Alatau was carried out in field expedition studies of the mountainous territory of Kazakhstan. The mountain vegetation of the Kyrgyz Alatau actively ripens in June-July, therefore, this period is the most favourable time for calculations. The accumulated data of floral monitoring allowed filling in and clarifying the systematics of the general species structure of the area, which will make up the materials of the following sections of the article.

MATERIALS AND METHODS

The process of research of scientific literature started from the analysis and synthesis of the necessary theoretical data of biological, ecological and geographical literature. Using the method of analogies, the research data of modern domestic and foreign scientists were compared. As diagnostic tools, the deductive and inductive method of observing the territory, traditional for geobotany, was used. In the case of this study, the analysis of the flora of the western part of the Kyrgyz Alatau. The study of the experience of research institutes, regulatory and educational documentation shows the lack of indicators of vegetation diversity over the past 30-40 years. The method of calculating arithmetic averages was used as mathematical methods. Techniques of graphical representation of the results were also used. The material of this article was our own collections and observations conducted in the period 2018-2020, and generalisations of all available literary sources and herbarium material on the western part of the Kyrgyz ridge, stored in various scientific institutions of the Republic of Kazakhstan and Kyrgyzstan. In the process of work, herbarium materials from the Biological Institute of the National Academy of Sciences of the Kyrgyzstan Republic and the Institute of Botany and Phytointroduction of the Academy of Sciences of the Republic of Kazakhstan were studied. The study was carried out in several stages. At the initial, ascertaining stage, the author was preparing for research work. Herbarium material was studied, in the full volume of literary data. The objectives of this study include clarifying the species composition of the flora of the gorges indicated in the title of this article, namely, the general characteristics of the species structure of plants growing in the western part of the Kyrgyz Alatau. In the literature data of domestic works, there is a lack of methods that allow analysing the similarity of flora on the territory of the Sandyk, Araltobe, Shaisandyk and Merke mountains.

At the next, formative stage, the parameters of the general species structure of plants growing in the western part of the Kyrgyz Alatau were described. The species were determined according to the collection "Flora of Kazakhstan" (Lazkov *et al.* 2016), the classification was carried out by deductive method combining plants into sections – families – genera – species. The systematic, areological and biomorphological structure of the flora was considered. The inventory was carried out according to the type of vegetation, the structure of aboveground shoots and the depth of the root system. A comparative analysis of the Sandyk, Araltobe, Merke and Shaisandyk gorges was carried out using the Jacquard community coefficient according to the formula:

$$K = \frac{C}{A+B-C} \quad (1)$$

where, K is the coefficient of generality, A is the number of species in the first surveyed territory, B is the number of species in the second surveyed territory, C is the number of species common to the first and second territories. This method facilitates data processing and interpretation of the results. The statistically important mean is preserved; quantitative comparisons are more specifically carried out between the long-term regimes of vegetation conditions in individual regions; the correlation between vegetation development spaces is more accurately diagnosed. At the third, control stage of the study, 3 average values of the coefficient of floristic generality of the analysed gorges Merke, Araltobe, Sandyk and Shaisandyk were obtained. The work analysed the vast territory of the general direction of changes in the state of vegetation and formed a general characteristic. According to the results of flora studies, we can talk about changes in the climatic conditions of the gorges of the Kyrgyz Alatau in connection with the deterioration of vegetation in this region. The reason for this is the primary interaction with atmospheric currents carrying moisture from the west. The western part of the Kyrgyz Alatau with its gorges and sparse vegetation has the appearance of a tunnel through which moisture and strong wind sweep. The mountain range does not perform its effective function of preserving flora from unfavourable climatic conditions.

RESULTS AND DISCUSSION

The western part of the Kyrgyz Alatau is a relief with clear steep slopes, standing out in sharp contrast to the foothill plain. By itself, the Kyrgyz ridge on the map charts is a narrow strip against the background of the massive ridges of the Northern Tien Shan (Fig. 1). The most striking feature of the vegetation cover of the Sandyk, Araltobe, Shaisandyk and Merke gorges is the wide development of high-grass mid-mountain meadows. Subalpine and alpine meadows are located on the slopes of the northern exposures, above 3000-3200 m, alternating with rocks and scree devoid of vegetation. From the western side (where the warm continental cyclone comes from), the gorges are exposed to warm and dry foehn winds that cause thaws. Foehn winds occur on the plateau, south of the western part of the ridge and affect the northern slopes with heat and dryness. Mountain breezes arising from the heating of the valley by the daytime sun regulate the speed of the wind direction in the gorges: during the day it is northern, and at night it turns from the south. Climatic conditions have an impact not only on the nature of vegetation, but also on the presence of certain dynamics between the vegetation states of different parts of the analysed territory. The results of the field survey, the analysis of literary data and the study of herbarium material allowed concluding that 835 species belonging to 336 genera and 78 families were registered in the territory of the western part of the Kyrgyz Alatau (Table 1).

Table 1. Distribution of plants of the western part of the Kyrgyz Alatau by systematic groups.

Sections	Families	Number of births	Number of types	Rate (%) of the total number of species
Equisetophyta	1	1	2	0.24
Polypodiophyta	2	5	7	0.84
Pinophyta	3	3	5	0.60
Magnoliphyta	72	327	821	98.3
Total	78	336	835	100

The above systematic groups (Table 1) show that the basis of the flora is flower (Magnoliphyta), while the minimum part is horsetail (Equisetophyta), ferns (Polypodiophyta) and gymnosperms (Pinophyta) respectively. The leading families are the Poaceae Barnhart families (Table 2), Fabaceae Lindl, Asteraceae Dumortier, Scrophulariaceae Juss, Caryophyllaceae Juss, Lamiaceae Lindley, Ranunculaceae Juss, Brassicaceae Burnett, Ranunculaceae Juss., Apiaceae Lindley, Boraginaceae Juss.

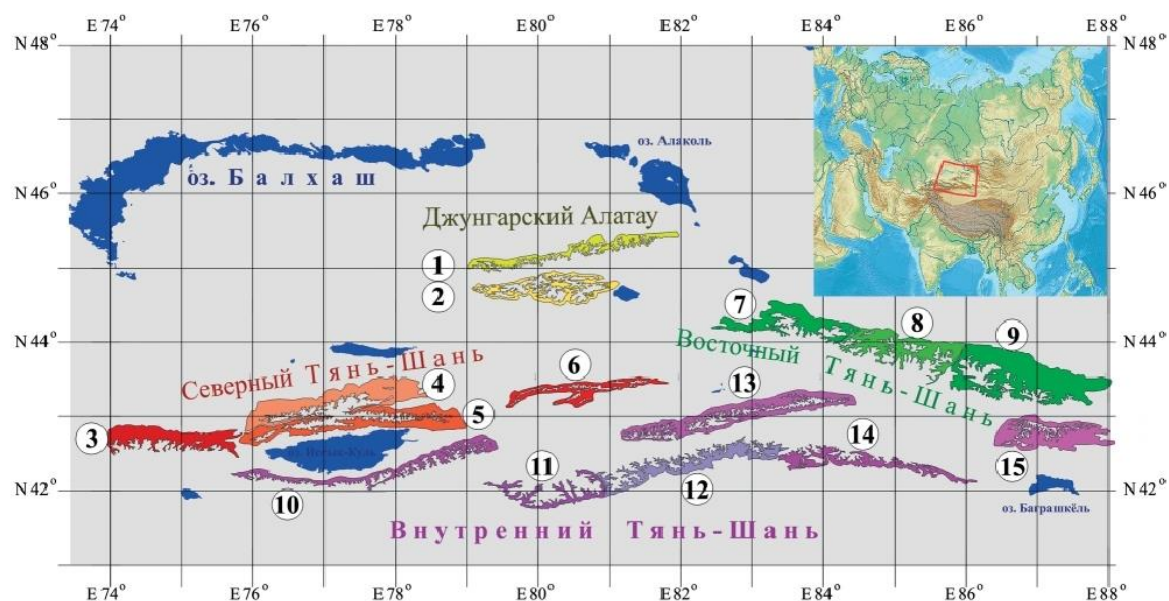


Fig. 1. Cartography of the location of the Tien Shan Mountain ranges. Note: Dzungarian Alatau: 1 – Northern Ridge, 2 – Southern Ridge in the Northern Tien Shan, 3 – Kirghiz Ridge, 4 – Trans-Ili Alatau, 5 – Kungei Alatau, 6 – Ketmen in the Eastern Tien Shan, 7 – Boro-Horo Ridge, 8 – Eken Habyrga, 9 – Uken Ridge in the Inner Tien Shan, 10 – Terskey Alatau, 11 – Kokshaal Tau, 12 – Halyk Ridge, 13 – Narat Ridge, 14 – Borohotan Ridge, 15 – Borto-Ula mountains.

Table 2. The general species structure of plants growing in the western part of the Kyrgyz Alatau.

No.	Families	Number of births	Number of types	Rate (%) of the total number of species
1	Equisetaceae Rich. Ex DC.	1	2	0.24
2	Botrychiaceae Horan.	1	1	0.12
3	Polypodiaceae Bercht.et J. Presl.	5	7	0.84
4	Ephedraceae Wettst.	1	2	0.24
5	Pinaceae Lindl.	1	1	0.12
6	Cupressaceae Neger.	1	2	0.24
7	Ranunculaceae Juss.	12	36	4.32
8	Berberidaceae Juss.	2	4	0.48
9	Paeoniaceae Rudolphi.	1	2	0.24
10	Papaveraceae Juss.	4	9	1.08
11	Fumariaceae A. P. de Candolle.	2	7	0.84
12	Caryophyllaceae Juss.	12	41	4.92
13	Chenopodiaceae Vent.	6	12	1.44
14	Polygonaceae Juss.	7	22	2.64
15	Plumbaginaceae Juss.	1	1	0.12
16	Betulaceae S. Fisch. Gray.	1	3	0.36
17	Primulaceae Vent.	4	6	0.72
18	Violaceae Batsch.	1	4	0.48
19	Tamaricaceae Link.	1	1	0.12

20	Salicaceae Mirb.	1	5	0.60
21	Capparidaceae Juss.	1	1	0.12
22	Brassicaceae Burnett	21	32	3.84
23	Cistaceae Juss.	1	1	0.12
24	Tiliaceae Juss.	1	1	0.12
25	Malvaceae Juss.	3	4	0.48
26	Ulmaceae Mirb.	1	1	0.12
27	Urticaceae Juss.	1	1	0.12
28	Euphorbiaceae Juss.	1	3	0.36
29	Crassulaceae DC.	4	14	1.68
30	Saxifragaceae Juss.	2	7	0.84
31	Parnassiaceae S. Fisch. Gray	1	2	0.24
32	Grossulariaceae DC.	1	3	0.36
33	Rosaceae Juss.	8	22	2.64
34	Lythraceae J. St.-Hil.	1	1	0.12
35	Onagraceae Juss.	1	4	0.48
36	Fabaceae Lindl.	14	65	7.80
37	Aceraceae Lindl.	4	9	1.08
38	Hippocastanaceae DC.	1	1	0.12
39	Rutaceae Juss.	2	2	0.25
40	Zygophyllaceae R. Br.	1	1	0.12
41	Anacardiaceae Lindl.	1	2	0.24
42	Linaceae DC. ex S. F. Gray.	1	4	0.48
43	Geraniaceae Juss.	2	3	0.36
44	Balsaminaceae A. Rich.	1	2	0.24
45	Polygalaceae R. Br.	1	1	0.12
46	Celastraceae R. Br.	1	1	0.12
47	Santalaceae R.Br.	1	1	0.12
48	Rhamnaceae Juss.	1	1	0.12
49	Elaeagnaceae Juss.	1	1	0.12
50	Apiaceae Lindley.	19	23	2.76
51	Caprifoliaceae Vent.	2	10	1.20
52	Valerianaceae Batsch.	3	7	0.84
53	Dipsacaceae Lindl.	2	4	0.48
54	Rubiaceae Juss.	4	9	1.09
55	Gentianaceae Juss.	2	8	0.97
56	Solanaceae Hall	4	6	0.72

57	Convolvulaceae Juss.	1	2	0.24
58	Boraginaceae Juss.	15	25	3.03
59	Scrophulariaceae Juss.	6	37	4.44
60	Plantaginaceae Juss.	1	2	0.24
61	Verbenaceae J. St.-Hil.	1	1	0.12
62	Lamiaceae Lindley.	16	30	3.60
63	Campanulaceae Juss.	1	2	0.24
64	Asteraceae Dumortier	51	141	16.9
65	Butomaceae S. F. Grey.	1	1	0.12
66	Alismataceae DC.	2	3	0.36
67	Juncaginaceae Lindl.	1	2	0.24
68	Potamogetonaceae Engl.	2	8	0.96
69	Najadaceae Benth. et Hook f.	1	1	0.12
70	Iridaceae Lindl.	3	5	0.60
71	Alliaceae J Agardh	1	14	1.68
72	Orchidaceae Juss.	2	5	0.60
73	Juncaceae Juss.	2	6	0.72
74	Cyperaceae Juss.	5	15	1.82
75	Poaceae Barnhart.	41	106	12.48
76	Lemnaceae Dumort.	1	1	0.12
77	Sparganiceae Engl.	1	1	0.12
78	Typhaceae J. St. Hil.	1	2	0.24
Total amount: 78		336	835	100

The largest genera are *Artemisia*, *Astragalus*, *Veronica*, *Potentilla*, *Silene*, *Carex*.

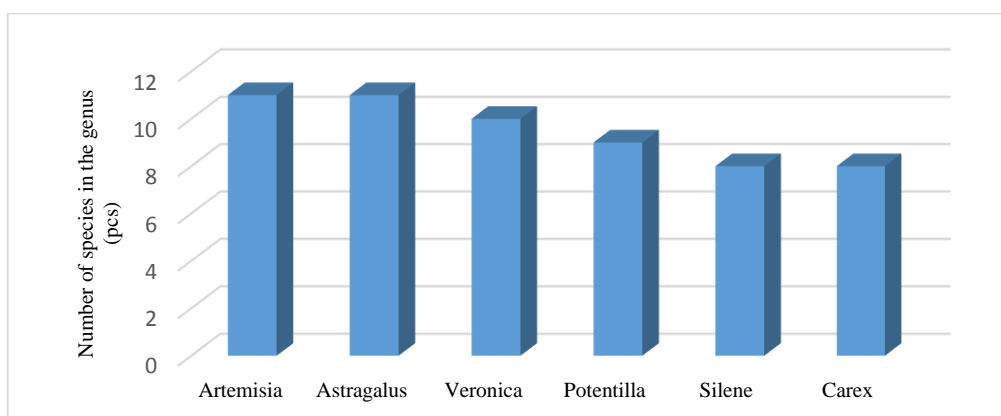


Fig. 2. Groups of leading genera of the western part of the Kyrgyz Alatau

Table 3. Classification of plant representatives by life forms.

Life form	Number of species (pcs).	% of the total number of species
Trees	16	1.92
Shrubs	36	4.32
Shrubs	10	1.20
Semi - villages	6	0.72
Herbaceous perennial plants	560	67.98
Herbaceous biennial plants	27	3.24
Herbaceous annual plants	166	19.92
Herbaceous one- and biennial plants	6	0.72
Herbaceous single- and perennial plants	4	0.48
Herbaceous biennial and perennial plants	4	0.48
Total	835	100

The largest number of representatives in terms of plant life form are herbaceous perennial plants. The rest of the territory is occupied by semi-shrubs and shrubs (wormwood, solyanka, ephedra, rare thickets of saxaul). Vegetation occupies 5-10% of the territory. The forests of the western part of the Kyrgyz Alatau occupy the peripheral part of the ridge in combination with meadows and steppes and are very rare. The peculiarities of the climate and soil do not allow forest-type plants to take root in large arrays on this territory. The forest-forming breed – spruce is located in the middle highlands in the interior areas closer to the sites of the northern exposure. In combination with various grasses (geranium, cuff, iris), forests are located along the bottoms of wide valleys in more illuminated areas. To solve the task set by the authors – an interregional comparison of long-term dynamics of vegetation conditions, it was decided to use the groups of genera (illustrated in Fig. 1) similar in species composition in the Sandyk, Araltobe, Merke and Shaisandyk mountains. The results of mathematical data showed that the flora of Mount Sandyk has a coefficient of commonality with the flora of Mount Shaisandyk – 0.23 (the number of common species is 171), with the flora of Mount Merke – 0.32 (the number of common species is 316). Obviously, the coefficient of generality is higher conditioned upon similar climatic conditions, which affect the exogenous processes of mountain ranges. Interregional correlations record a relative deterioration of vegetation conditions in the area of Mount Shaisandyk. The analysis of the spatial structure in studies of vegetation conditions in the western part of the Kyrgyz Alatau, conducted through a comparison of the regimes of its constituent gorges (Merke, Araltobe, Sandyk, Shaisandyk) showed the internal homogeneity and consistency of the dynamics of these parts. The difference between this mountain system is that it is the first to interact with atmospheric currents that carry moisture. The decrease in vegetation in this ridge is explained by the authors as a consequence of a decline in the resistance of the advanced ridges with western transport and an elevation in the amount of moisture entering these zones. During these years, temperature inversions are observed in winter, leading to the development of low cloud cover and clear skies in the high-altitude zone. The climate of the area strongly depends on the circulation processes of the atmosphere. The peaks of mountain systems delay the inflow of air from the Atlantic and powerful cyclones form there. The different level of the snow line, due to the upraised humidity (Fig. 2) exhibits the internal structure of the dynamics of the vegetation conditions of the Kyrgyz Alatau in the aspect of its individual constituent ridges.

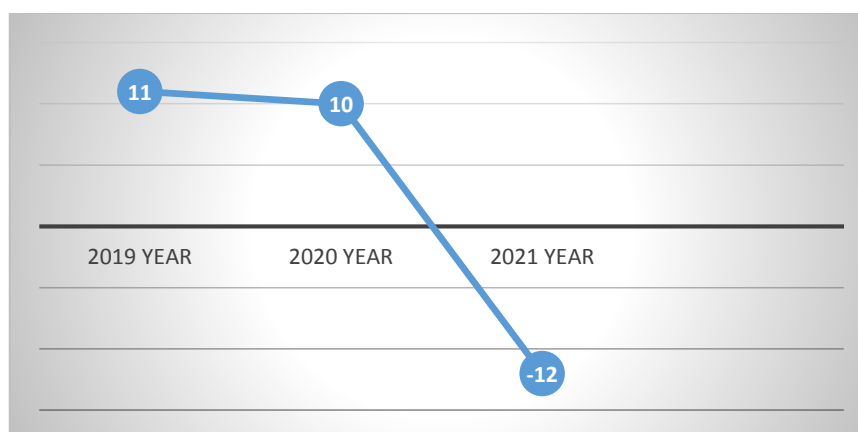


Fig. 3. Dynamics of differences in vegetation conditions (difference in VCI indices) in the period 2019-2021 between the gorges of Merke, Araltobe, Sandyk, Shaisandyk and the region as a whole according to the results of the study.

At the moment, the studies covered in this article will allow making a positive contribution to the dynamics of studying the state of vegetation in this region. The research results suggest that the average annual temperature and precipitation are rapidly increasing. The reason for this may be the fact that global warming has played a role in the vegetation of the western part of the Kyrgyz Alatau. As mentioned above, the peculiarities of the location of the ridge complicate its resistance to the warm condition of the continental climate. Central Asia forms large warm air masses, from which powerful mountain systems have protection. However, the funnel-shaped entrance of the gorges Merke, Sandyk, Chasandyk receives all streams of warm air. Precipitation is the main limiting factor of vegetation development in the middle zone of the gorges, while temperature is on the upper one. Such a reaction of flora to growth is the result of stress caused by drought and high temperature in the upper zones over the past 10 years (Terekhov *et al.* 2019). The total composition of the flora of the western part of the Kyrgyz Alatau gorges of the Merke and Karakystak rivers is represented by 548 species 298 genera 82 families, which constitutes a third of the entire flora of the western tip of the Kyrgyz Alatau, numbering about 1500 species (Nelina 2005; Kudabayeva 2022; Nelina *et al.* 2022). The experience of foreign national parks in the USA, Canada, China and Russia (Li *et al.* 2015; Feng *et al.* 2016; Ning *et al.* 2017; Zhang *et al.* 2018) suggests that the inclusion of observations in the plant monitoring system will increase the effectiveness of practical measures for the protection and management of flora. The study of climate change is necessary to assess the dynamics of climate and to create forecasts of their variability in the future. To do so, it is necessary to select optimal criteria for quantitative and qualitative characteristics of natural changes in order to population rare plant species. Tectonic plates are mobile, therefore, currently the mountain-building process continues. Every year the mountains rise by 5 mm per year. The continental climatic conditions of the foothill plains are characterised by amplitude temperature fluctuations and moderate precipitation. Field expedition studies allow identifying the quantitative composition of vegetation growth from climate variability. Long-term research data can be used to clarify regional and global vegetation changes and model its variability in the future. The amount of annual plant growth depends on a number of internal and external factors, including climatic, biological features of different plant species, growing conditions, solar radiation, completeness of planting, fruiting, natural phenomena. The growth of species correlates with such factors as fluctuations in temperature and humidity of the external environment, the intensity of lighting. Currently, this issue has been poorly studied and requires additional discussion aspects. However, the fact that pronounced morphological features of individual plant species react to climatic changes is shown in this article and has been unanimously recognised by many researchers. Further, the authors give examples of the species diversity of the morphological constitution of the flora, which is explained by a wide range of environmental conditions. Based on the geomorphological characteristics, the author distributed the vegetation of individual zones as follows. The flat part is represented by thickets of saxaul, salt marshes found in places. The main types of landscape include mountain steppes and semi-deserts, their predominance causes the dryness and continentality of the climate. The slopes of the foothill plains and the foothills of the ridges are the most arid areas. Deserts with semi-deserts are located in intermountain basins. Salt marshes and areas of stony-gravelly deserts, loess and loess-like loams are rich in low-humus grey soils. We can consider the characteristics of vegetation species in the belts of the western part of the Kyrgyz Alatau based on the Atlas of Flora and Fauna of the Kyrgyz Republic (Lazkov

2016; Table 4). In the western part, precipitation falls mainly in the spring. Flora is represented by ephemera and ephemerooids: mint, desert sedge, astragalus. Vegetation occupies 50% of the gorges. It mainly consists of wormwood, tipchak, grasshopper, granary. Closer to the south of the western part are subtropical steppes with growing tall grass. Intermountain depressions conditioned upon high humidity are rich in dark chestnut soils with grass-grass meadow-steppes. The surface of which is 80-90% covered with vegetation, mainly tansy-sheep fescue and tansy-tirs-sagebrush steppes. The landscape of the upper belt is represented by glacial deserts, where vegetation is completely absent. The exception is the slopes of the northern exposure of this site (conifer Regel grows on the upper pebble and rocky belts of the mountains, a branch; fir tree, grows in the mountains, wood, spores (Gulnara et al. 2020; Tojibaev et al 2020). The preservation of the forest system is important for the whole of Kazakhstan. To date, this is a priority for all national parks of the studied region. Since the gorges of Merke, Araltobe, Sandyk and Shaisandyk are not rich in forest vegetation, the most common representatives of conifers in this territory are fir and fir Sherenka. These two representatives of coniferous trees need to be preserved as a species. The type of fir tree grows up to 40 m in height and 100 cm in radius. The root system is extensive, located not deep, morphologically plastic. This species provides successful dendrochronological indicators in the study of the relationship between long-term climatic changes and the response of tree growth to it (Utebekova 2021). The radial growth of the annual rings of spruce is sensitive to climate changes.

Table 4. Characteristics of the species vegetation of the mountain belts of the western part of the Kyrgyz Alatau.

Belt	Height (m.)	Nature of the territory	Representatives of the species
Plumes and low mountains	1600	Desert and semi-desert herbage; Wormwood-ephemeral vegetation	maidenhair spleenwort. it grows in crevices of rocks, rocky slopes, wetlands, perennial, VII-VIII; maidenhair desert grows in crevices of rocks, in the shade of the subalpine zone, perennial, spores VI-VIII; Wormwood, grasshopper communities, Potashnik, Karagana – covers 15-25% of all surfaces
Middle mountains, mountains-meadow-steppe	1600-2500	Steppes and tall grass meadows with thickets of shrubs	Turkestan juniper, fruiting VII-VIII, wood; two-pronged conifer grows on rocky slopes in the lower and middle belt of the mountain, branch, flowering VI; Zevarshan juniper grows in the lower and middle arid zone of the mountains, perennial, fruiting VIII-IX, wood; semilunar bunch (fern), perennial, spores VI-VIII; common tansy grows in rock crevices and mossy cover, perennial, spores VI-VII
High Mountains	2500-4500	Subalpine steppes with flora of subalpine and alpine meadows, Kobrezievnikami and Nival vegetation	Rare mosses and lichens

Some species of deciduous trees are also common in this area: *Sorbus tianschanica* Rupr., *Betula pendula* Roth, *Betula tianschanica* Rupr. *Juniperus turkestanica* Kom and *Juniperus seravschanica* Kom are found in the subalpine belt. Of the Red Book plants, the following species predominate (Terekhov et al. 2015; Salnikov et al. 2015) barberry pedunculate, leaves along the edge are prickly-toothed; fruits are red, without plaque; ovary is broadly elliptical; thorns are 1-9 separate. Shrub up to 2 m in height. The change in climatic conditions in the present and future is due to the anthropogenic impact of human on nature. The new natural environment is the result of human activity (Terekhov et al. 2015; Yushin 2017). The experience of natural and man-made disasters has serious socio-ecological consequences. Scientific and technological progress has encountered previously unknown obstacles. Environmental disasters are of a large-scale nature, and a person's attitude to them is the key to solving them. Unfortunately, a person does not always realise this. After all, it is human who, by his actions, aggravates the difficulties of the ecological situation in the world. The forest system protects the surrounding area from temperature changes (and we know that in the mountains the air cools very quickly and also warm up), and seasonal frosts, which plays an important role in preserving the fertility of the soil of agricultural land. Experts note a mild climate in those zones where there is more vegetation (Zhumanova et al. 2018). The identification of risks leading to environmental disasters has an impact on the economic situation of the Republic of Kazakhstan. By implementing the concept of "Strategy 2030", the goal of which is the harmonious interaction of human with the environment, the chances of efficient use of resources increase, life expectancy increases, and the opportunity

to reach the standard of living of developed European countries is created. Nature-saving technologies should be a strategic guideline of the state policy of the country.

CONCLUSION

The study of various groups of plants in the gorges of Merke, Araltobe, Sandyk and Chaisandyk in the western part of the Kyrgyz Alatau allowed us to know the general development of flora, to outline the main stages of its formation. In the course of field expedition studies, 835 species, 336 genera, and 78 families of plants growing in the Merken district, Zhambyl region were identified. The systematic structure allows attributing the studied flora to the flora on the territory of the Sandyk, Araltobe, Shaisandyk and Merke mountains in the western part of the Kyrgyz Alatau. Magnoliophyta taxon has the largest percentage of representatives – 98.3%. Large representatives of the genus are – *Artemisia*, *Astragalus*, *Veronica*, *Potentilla*, *Silene*, *Carex*. The coefficient of floristic generality showed similarity in the species diversity of vegetation between the gorges of Merke and Sandyk. The coefficient of floristic generality of the Sandyk and Shaisandyk mountains is lower, which was influenced by the transitional nature of the areological structure of the flora from desert – semi-desert to subalpine and alpine meadows. Deterioration of the conditions of growth and development of natural vegetation on the ridges that make up the region, there may be a decrease in the effectiveness of the western part of the Kyrgyz Alatau interception of precipitation. A large proportion of moisture reaches the upper mountains and lingers there in the form of glaciers and snowfalls. In addition, conditioned upon the lack of extensive forest areas, subalpine and alpine meadows are subject to a large amount of solar radiation. Such climate fluctuations, according to the authors, occur against the background of global warming. Therefore, precipitation has a positive effect on the vegetation of subalpine and alpine steppes, which cannot be said about coniferous and deciduous forests, since increased humidity leads to carious processes of young animals and a decrease in the radial growth of spruce, while elevated temperatures burn out grass stands for June-July and favourably affect the growth of trees. For these reasons, the vegetation of this region is quite sparse. The research results are aimed at attracting interest in the system of conservation and protection of nature in poorly studied regions. The elevation of such regions to the status of national parks and reserves based on the experience of Western colleagues. The author scientifically substantiated the need to organise a monitoring system for the red book plants of subalpine meadows, coniferous forests. The obtained research data can be used by historians, archaeologists, and botanists. In general, the spectrum of the leading flora families of the region differs from the largest families of anthropophilic flora elements. In terms of life forms, there is a predominance of perennial herbaceous plants.

REFERENCES

- Aghajani, MS, Oskoueian, R, Naqinezhad, A, Asadi, M, Serpooshan, F 2023, A floristic study of Garasmasar Mountains: Mazandaran Province, Iran. *Caspian Journal of Environmental Sciences*, 21: 693-709.
- Bubyreva, V & Byalt, V 2018, Collection of Carl L. Willdenow (1765-1812), kept in the herbarium of St. Petersburg State University (LECB) and an attempt to systematize it. St. Petersburg. Botany in the modern world. Proceedings of the XIV Congress of the Russian Botanical Society and the Conference, *Botany in the Modern World*, 1: 16-18.
- Feng, C, Qing, H, Mambetov, B, Maisupova, B & Kelgenbayev, N 2016, Drought variations in Almaty (Kazakhstan) since A.D. 1785 based on spruce tree rings. *Journal's Editorial Office (JEO) Springer Nature*, 45: 145-155.
- Gulnara, T, Gulmira, S, Kudabayeva, L, Dimeyeva, N, Gemejiyeva, P & Vesselova, V 2020, Crop wild relatives of Kazakhstani Tien Shan: Flora, vegetation, resources Institute of Botany and Phyto-introduction. *Kazakhstan Plant Diversity*, 42: 19-32.
- Lazkov, G, Davletbakov, A, Milko, D & Ganybaeva, M 2016, Atlas of flora and fauna of specially protected natural areas of the Central Tien Shan (Kyrgyz Republic). Bishkek: UNDP.
- Li, C, Chi, Z, Geping, L, Xi, Ch, Maisupova, B, Abdullo, A, Qifei, H & Bekmamat, M 2015, Carbon stock its responses to climate change in Central Asia. *Global Change Biology*, 21: 1951-1967.
- Muzylev, E, Startseva, Z, Zeiliger, A, Ermolaeva, O, Volkova, E & Vasilenko, E 2019, Using satellite data on the characteristics of the underlying surface and meteorological characteristics in modelling the water and thermal regimes of a large agricultural region. *Modern Problems of Remote Sensing of the Earth from Space*, 16: 44-60.

- Nelina, NV 2005, Analysis of tree and shrub flora of the Kyrgyz Alatau. 224 p.
- Nelina, NV, Kudabayeva GM, Mukhtabayeva SK & Bilibayeva, Bk 2022, The species composition of the flora of the Merke and Karakystak gorges of the western part of the Kyrgyz Alatau./Problems of botany of Southern Siberia and Mongolia. XV International Scientific and Practical Conference, pp. 392- 398.
- Ning, L, Liu, J & Sun, W 2017, Influences of volcanic eruptions on Asian summer monsoon over the last 110 years. *Arid Zone Research*, 5: 12-14.
- Nowak, A, Świerszcz, S, Nowak, S & Nobis, M 2020, Classification of tall-forb vegetation in the Pamir-Alai and western Tian Shan Mountains (Tajikistan and Kyrgyzstan, Middle Asia). *Vegetation Classification and Survey*, 1: 191-217, <https://doi.org/10.3897/VCS/2020/60848>.
- Rui, L, Wang, Y, Jiang, S, Zhang, R & Qin, L 2019, Radial growth of trees in response to climatic factors in the Altay Mountains. *Arid Zone Research*, 36: 723-733.
- Salnikov, V, Turulina, G, Polyakova, S, Petrova, Y & Skakova, A 2015, Climate change in Kazakhstan during the past 70 years. *Quaternary International*, 3(12): 77-82.
- Terekhov, A, Vitkovskaya, I, Abaev, N & Dolgikh, S 2019, Long-term trends in the state of vegetation of the Tien Shan and Dzhungarskiy Alatau ridges according to eMODIS NDVI C6 data (2002-2019). *Modern Problems of Remote Sensing of the Earth from Space*, 16: 133-142.
- Tojibaev, K, Jang, Ch, Lazkov, G, Chang, KS 2020, An annotated checklist of endemic vascular plants of the Tian-Shan mountains in central Asian countries. *Phytotaxa*, 464: 117-158.
- Utebekova, A 2021, Investigation of the influence of climatic conditions on the Schrenk spruce (in the Northern Tien Shan) by methods of dendrochronology. Almaty: KNAU.
- Utebekova, A, Adilbaeva, Zh, Maisupova, B, Abaeva, K & Kentbayeva, B 2019, Annual rings of woody plants as indicators of climatic environmental conditions. 2nd International Eurasian Conference on Biological and Chemical Sciences (Eurasian Bio Chem 2019). Ankara: Eurasian Research, Development, Science and Technology Centre.
- Zhang, R, Qin, L, Shang, H, Yu, S & Gou, X 2020, Climatic change in southern Kazakhstan since 1850 C.E. inferred from tree rings. *International Journal of Biometeorology Springer Link*, 64: 12-13, ISSN 0020-7128, DOI 10.1007/s00484-020-01873.
- Zhang, T, Zhang, R, Lu, B, Maisupova, B, Bulkajyr, M, Kelgenbayev, N, Dosmanbetov, D, Chen, F & Yu, S 2018, Tree-ring chronologies development and vegetation index reconstruction for the Alatau mountains, Central Asia. *Geochronometria*, 45: 107-118, <https://doi.org/10.1515/geochr2015-0091>.

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