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## Species diversity of wild fruit plants of the natural flora of the Kazakh Altai

The purpose of this work was identification of modern species diversity of wild fruit and berry plants in the flora of the Kazakhstan Altai and their ranking according to a set of biological indicators. As a result of studying the biodiversity of vascular plants of the Kazakhstan Altai, using the route-reconnaissance method, it was established that 52 species of fruit and berry plants belonging to 22 genera and 12 families grow on its territory. The largest number of species taxa is represented by 3 families: Rosaceae, Caprifoliaceae, Grossulariaceae, which contain 29 species, which is 55.77 % of the total. Among plant communities with the participation of fruit and berry species, forest (26 %) and meadow associations (23 %) occupy a dominant position, synanthropic phytocenoses with the participation of *Solanum dulcamara* and *S. nigrum* are also established in abandoned garden plots of settlements in the region. The growth of 7 alien fruit and berry species was identified: *Alkekengi officinarum*, *Berberis vulgaris*, *Malus baccata*, *Ribes aureum*, *Sambucus racemosa*, *Sorbus aucuparia*, *Symphoricarpos albus*, of which only *Malus baccata* formed its own communities. According to life forms, fruit and berry species are represented by trees, shrubs, dwarf shrubs, subshrubs, and herbaceous perennials. Shrubs dominate by 36 species (69.2 %). In relation to the moisture factor, the identified species are ranked by 6 ecological groups, where mesophytes predominate — 36 species (69.2 %). Of the fruit and berry species, 3 species are currently protected at the state level: *Daphne altaica*, *Paris quadrifolia* and *Vaccinium microcarpum*, included in the Red Book of Kazakhstan with the status of rarity category II.

**Keywords:** life forms, alien species, Kazakhstan Altai, location, fruit and berry plant species, ecological groups.

### Introduction

Along with the Convention on Biodiversity, which provides special attention to the issues of studying, preserving and protecting biological diversity as a guarantor of ecosystem sustainability, in 2002 the 6th Conference of the Parties to the Convention adopted the Global Strategy for Plant Conservation (GSPC). At the same time, the second target setting defines the task of regional plant protection, which would take into account the specifics of the regions, since the ongoing process of global climate change and anthropogenic pressures threaten the preservation of natural vegetation and the habitat itself. At the present stage, research on the study of the genetic potential of wild fruit and berry plants and the preservation of their gene pool for solving food security, in the implementation of monitoring for the implementation of scientifically based conservation measures are relevant.

The aim of our research was to identify the modern species diversity of wild fruit and berry plants in the flora of the Kazakh Altai and to rank them according to a set of biological indicators.

Kazakhstan Altai within the East Kazakhstan region, with an area of about 200 thousand km<sup>2</sup>, in accordance with the classification adopted in the academic publication “Flora of Kazakhstan” (1956), belongs to the floristic region 22. Altai. The geographical position of the region, its geological structure, complexity and diversity of relief, as well as soil-climatic and hydrological conditions determine its division into 3 physical-geographical regions: Southern Altai (Narymsky, Sarymsakty, South Altai Tarbagatai, Kurchumsky, Azutau, Southern Altai, Kabinsky and Bukhtarma Mountains ranges); Western Altai (Ivanovsky, Ulbinsky, Ubinsky, Koksinsky, Lineisky, Kholzun, Zapadnaya Listvyaga ranges); Kalbinsky Altai (Eastern mountain-forest Kalba, Western mountain-steppe Kalba) [1].

### Experimental

To obtain more complete information on the species diversity of wild fruit and berry plants in the study area, literary data were analyzed [2–7]; herbarium materials of the Altai Botanical Garden (Ridder), East Kazakhstan Technical University (Ust-Kamenogorsk), Katon-Karagay National Nature Park, Markakol State Nature Reserve, as well as materials of our own long-term developments in the East Kazakhstan region in the administrative districts: Altai, Glubokovsky, Zaysansky, Katon-Karagaysky, Kurchumsky, Samara, Tarbagataisky, Ulansky, Shemonaikhinsky.

The species composition of wild fruit and berry plants was studied using one of the traditional methods of floristic research — route reconnaissance [8]. Life forms of plants were assessed using the method of I.G. Serebryakov [9]. During the route research, floristic lists were compiled, the nature of the species distribution was revealed and biological and economic indicators were determined. The names of the accepted genera and species of wild fruit and berry plants were verified using data from the Plants website of the World Online [10]. The authorship of species, genera and families is given according to the International Plant Names Index [11]. When compiling expedition routes, geographic areas characterized by floristic diversity were taken as key territories. Ecological groups of plants were identified according to the classification of A.V. Kuminova [12]. When identifying individual groups of economically valuable plants, the following scientific publications were used: “Plant Resources of Russia ....” [13] and “Annotated List of Medicinal Plants of Kazakhstan” [14]. For a quantitative assessment of the introduction of alien plants into the local flora, the method proposed by L.V. Horun et al. [15] was used.

### Results and Discussion

The environmental conditions in the complex (climatic, edaphic, orographic, geological, hydrological) of the Kazakhstan Altai ensured a high species diversity of wild fruit and berry plants in the flora of the region. Targeted studies allowed us to identify the species composition of fruit and berry plants, and establish some patterns of their spatial distribution. Table provides a list of the species diversity of fruit and berry plant species and the identified actual places of their growth with coordinates on the territory of the Kazakhstan Altai. Based on the research results, the locations of 52 species of fruit and berry plants belonging to 22 genera and 12 families were established in the surveyed local flora. The general list also includes species of fruit and berry plants from the families: Cupressaceae Gray, Thymelaeaceae Juss., Ephedraceae Dumort., Melanthiaceae Batsch ex Borkh. with inedible fruits, but which are medicinal or rare.

Table

List of species diversity and locations of wild fruit plants of the Kazakh Altai

Family	Genus, species	Location	Latitude	Longitude	Height above sea level, m
Berberidaceae Juss.	<i>Berberis heteropods</i> Schrenk	North-western slope of the Saikan ridge, Aksiyr tract	47.40333	85.45583	1170
	<i>Berberis sibirica</i> Pall.	North-western slope of the Bukhtarma Mountains	49.18972	85.51944	820
	<i>Berberis vulgaris</i> L.	South-eastern spurs of the Ubinsky ridge, Mount Kozlushka	50.27639	83.28917	710
Caprifoliaceae Juss.	<i>Lonicera caerulea</i> subsp. <i>altaica</i> (Pall.) Gladkova	Foothills of the Ivanovsky ridge, Gray meadow tract	50.35775	83.89667	1211
	<i>Lonicera caerulea</i> subsp. <i>pallasii</i> (Ledeb.) Browicz	Bukhtarma Mountains, northwestern foothills, Berezovka River valley	49.51861	84.39306	535
	<i>Lonicera hispida</i> Pall. ex Schult.	Kholzun ridge	50.33722	84.11944	2025
	<i>Lonicera microphylla</i> Willd. ex Roem. & Schult.	Foothills of the Ivanovsky ridge, Gray meadow tract	50.3575	83.89667	1200
	<i>Lonicera stanant</i> Pojark.	Southern Altai Range, upper reaches of the Bukhtarma River	49.28834	86.56886	2020
	<i>Lonicera tatarica</i> L.	Ridge Narymsky, northwestern slope, Shertan tract	48.93444	83.71778	476
	<i>Symphoricarpos albus</i> (L.) K.Koch	South-eastern foothills of the Ulbinsky ridge	49.71944	83.86389	452
Cupressaceae Gray	<i>Juniperus communis</i> var. <i>saxatilis</i> Pall. Siberian	Foothills of the Ubinsky ridge, south-eastern spurs	50.24611	83.47194	1800
	<i>Juniperus pseudosabina</i> Fisch. & C.A. Mey.	North-western slope of the Ivanovsky ridge, upper reaches of the Bolshaya Poperechka river	50.32222	84.19056	1977
	<i>Juniperus sabina</i> L.	of the Lineisky ridge, upper reaches of the Barsuk river	50.27167	83.16528	820

Continuation of Table

Family	Genus, species	Location	Latitude	Longitude	Height above sea level, m
Elaeagnaceae Juss.	<i>Hippophae rhamnoides</i> L.	Narymsky ridge, northwestern foothills, Solonechnaya river valley	49.17389	85.51889	945
Ephedraceae Dumort.	<i>Ephedra dahurica</i> Turcz.	Kalbinsky ridge	49.71297	81.58365	649
	<i>Ephedra equisetina</i> Bunge	Zaisan depression, near the village of Birzhan	48.6825	84.2220	586
	<i>Ephedra intermedia</i> Schrenk & C.A. Mey.	Kalbinsky ridge (Western steppe Kalba)	49.50513	83.88988	650
	<i>Ephedra monosperma</i> J.G. Gmel. ex C.A. Mey.	Kurchumsky ridge, Kurchum river valley	47.8881	85.0481	410
Ericaceae Durande	<i>Vaccinium microcarpum</i> (Turcz. ex Rupr.) Schmalh. ex Busch	Bukhtarma Mountains	49.1887	85.5585	981
	<i>Vaccinium myrtillus</i> L.	Koksinsky ridge	50.40772	84.24028	1800
	<i>Vaccinium vitis-idaea</i> L.	Chindogatui Mountains, Berel River Valley	49.47417	86.39861	1260
Grossulariaceae DC.	<i>Ribes acicular</i> Sm.	Koksinsky ridge	50.37167	83.87722	1854
	<i>Ribes aureum</i> Pursh	Kalbinsky ridge (Eastern Kalba), Koktau Mountain, north-eastern slope	49.42889	82.66694	896
	<i>Ribes graveolens</i> Bunge	Kalbinsky ridge, (Eastern Kalba), Laila tract	49.07389	83.36639	620
	<i>Ribes nigrum</i> L.	Lineisky ridge, upper reaches of the Barsuk river	50.32222	84.19056	1977
	<i>Ribes petraeum</i> Wulfen	Ivanovsky ridge, north-western slope	48.60361	83.57639	467
	<i>Ribes rubrum</i> L.	Narymsky ridge, Kurchum crossing area	50.32028	84.19556	1934
Melanthiaceae Batsch ex Borkh.	<i>Paris quadrifolia</i> L.	Kara-Kabinskaya depression, vicinity of the village of Sogornaya, valley of the river Sogornaya	49.2510	85.3532	672
Rosaceae Juss.	<i>Cotoneaster melanocarpus</i> G.Lodd.	Eastern foothills of the Ubinsky ridge	50.32667	83.545	820
	<i>Crataegus chlorocarpa</i> Lenné & K.Koch	South-eastern spurs of the Ubinsky ridge, Mount Kozlushka	49.50167	83.05556	792
	<i>Crataegus sanguinea</i> Pall.	Kalbinsky ridge, Koktau mountains	49.17194	85.78139	1002
	<i>Fragaria vesca</i> L.	Kh. Kalbinsky (Eastern Kalba) ridge, Tainty tract	50.32694	83.54556	825
	<i>Fragaria viridis</i> Duchesne	Samrymsakty ridge, northwestern foothills, in the area of the village of Zhanaulgo	50.32417	83.55111	782
	<i>Malusbaccata</i> (L.) Borkh.	Foothills of the Ubinsky ridge, south-eastern spurs	49.18944	85.52028	895
	<i>Prunus padus</i> L.	Lineisky Ridge, north- western slope	50.26611	83.22889	523
	<i>Rosa acicularis</i> Lindl.	Foothills of the Ivanovsky ridge, Belkina mountain, south-eastern slope	48.39528	84.49278	525
	<i>Rosa laxa</i> Retz.	South-eastern foothills of the Ivanovsky ridge	50.27167	83.16528	727
	<i>Rosa spinosissima</i> L.	Foothills of the Ivanovsky ridge, Belkina mountain, south-eastern slope	50.27611	83.28917	715
	<i>Rubus caesius</i> L.	Bukhtarma mountains, river valley Solonechnaya, env. With. Katon-Karagay	49.3469	82.37256	1299
	<i>Rubus idaeus</i> L.	Kurchumsky ridge, Kalguta river valley	49.36639	85.51889	1125

Continuation of Table

Family	Genus, species	Location	Latitude	Longitude	Height above sea level, m
Rosaceae Juss.	<i>Rubus sachalinensis</i> H.Lev.	Kalbinsky Ridge, Koktau Mountains (Medvedka Mountain)	50.37111	84.10861	1456
	<i>Rubus saxatilis</i> L.	Bukhtarma mountains, river valley Solonechnaya, env. Katon-Karagay	49.28522	83.39082	776
	<i>Sorbus aucuparia</i> L.	Foothills of the Ivanovsky ridge, north- western slope	50.37472	83.88861	991
	<i>Sorbus aucuparia</i> subsp. <i>glabrata</i> (Wimm. & Grab.) Hedl.	Chindogatui mountains, Rakhmanovskie springs tract	48.47750	86.38944	1273
Solanaceae Juss.	<i>Alkekengi officinarum</i> Moench	Foothills of the Ubinsky ridge	50.63945	81.93744	315
	<i>Solanum dulcamara</i> L.	Ubinsky ridge, env. Shemonaikha	48.6454	84.0802	398
	<i>Solanum nigrum</i> L.	Valley of the river Black Irtysh, near the village of Buran	50.26139	83.22972	577
Thymelaeaceae Juss.	<i>Daphne altaica</i> Pall.	Foothills of the Azutau ridge, northern slope	48.42167	85.72472	1070
	<i>Daphne mezereum</i> L.	Ulbinsky ridge, Ridder area	50.24065	83.23428	980
Viburnaceae Raf.	<i>Sambucus racemosa</i> L.	South- eastern spurs of the Ubinsky ridge, Mount Kozlushka	50.27639	83.28917	710
	<i>Sambucus sibirica</i> Nakai	Foothills of the Ivanovsky ridge	50.37472	83.88861	890
	<i>Viburnum opulus</i> L.	Narymsky ridge, northwestern slope of the Shertan tract	48.93444	83.71778	476

Systematic analysis showed that the largest number of species taxa is represented by the families: Rosaceae Juss. — 16 species (30.77 %), Caprifoliaceae Juss. — 7 species (13.46 %), Grossulariaceae DC. — 6 species (11.54 %) (Fig. 1). These three families contain 29 species, which is 55.77 % of the total species diversity of wild fruit plants in the flora of the Kazakh Altai.

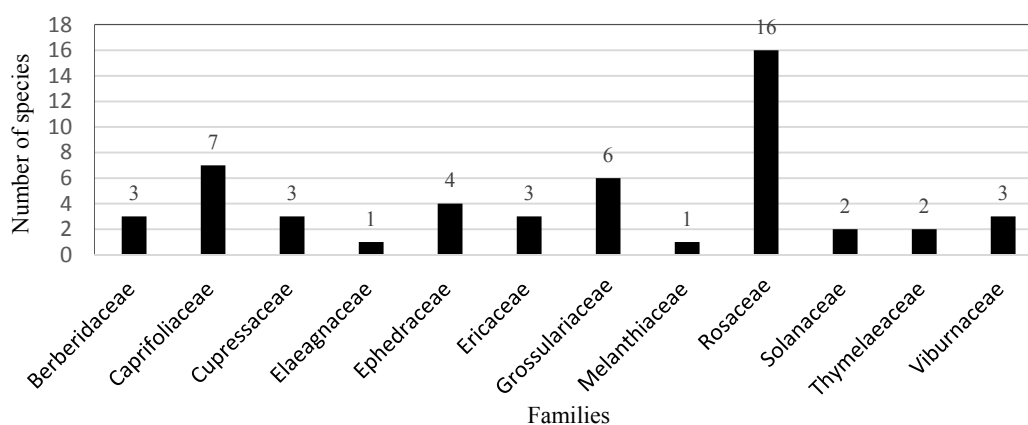


Figure 1. Quantitative composition of species taxa of fruit and berry plants of the Kazakh Altai by families

Formational analysis revealed that the flora coenotypes with the participation of wild fruit and berry plants in the studied region are represented by a wide spectrum, which is facilitated by the geographical position of the Kazakhstan Altai and altitudinal zonation. Among the plant communities with the participation of fruit and berry species, the dominant position is occupied by forest (26 %) and meadow associations (23 %).

Basically, these are dark coniferous, coniferous, and mixed and birch forests, different types of meadows (wet swampy, alpine, dry and damp forest, foothill forb-grass, forb-shrub steppe). Shrub associations with berry bushes are noted on the slopes of gorges, rocky screes in the mountain-forest and mountain-steppe belts.

Synanthropic phytocenoses formed on abandoned garden plots of populated areas were identified, where the subdominant species is *Solanum dulcamara* in the foothills of the Ubinsky ridge, near the town of

Shemonaikha and on the Kurchumsky ridge, in the vicinity of the liquidated village of Cherdoyak; *S. nigrum*- in the valley of the Black Irtysh River, in the vicinity of the village of Buran.

The monitoring carried out in 2021–2023 of the alien fraction in the flora of the Kazakh Altai revealed the growth of 7 alien fruit and berry species: *Alkekengi officinarum*, *Berberis vulgaris*, *Malus baccata*, *Ribes aureum*, *Sambucus racemosa*, *Sorbus aucuparia*, *Symphoricarpos albus*. Of the identified alien species, only *Malus baccata* has penetrated into the natural vegetation. The other above-mentioned species were previously cultivated plantings, but after the liquidation of settlements they became wild. At present, their degree of naturalization can be estimated at two points (colonophytes), since they do not spread beyond the places of introduction. Formation of a secondary range *Malus baccata* contributed to the primary introduction of species in the Altai Botanical Garden in 1939–1945. Due to the ecological plasticity and resistance to unfavorable factors, high winter hardiness and decorativeness, the species was widely used in landscaping the cities and villages of the region. At the present stage, *Malus baccata*, forming its own communities, is widely found in the Kazakh Altai [16, 17].

In terms of life forms, fruit plant species in the flora of the region are represented by trees, shrubs, dwarf shrubs, subshrubs and herbaceous perennials. Among them, shrubs occupy a dominant position — 36 species (69.2 %). The remaining groups are represented in small quantities: fruit trees — 6 species (11.53 %), dwarf shrubs — 4 species (7.69 %), herbaceous perennials — 4 (7.69 %), subshrubs — 2 (3.89 %).

In relation to the moisture factor, all identified fruit species were divided into 6 ecological groups: mesophytes, mesoxerophytes, xeromesophytes, xerophytes, mesohygrophytes, hygromesophytes (Fig. 2). In quantitative terms, mesophytes are represented by 36 species (69.2 %), the remaining 16 taxonomic species (30.8 %) belong to 5 ecological groups, with an almost equal ratio of species.

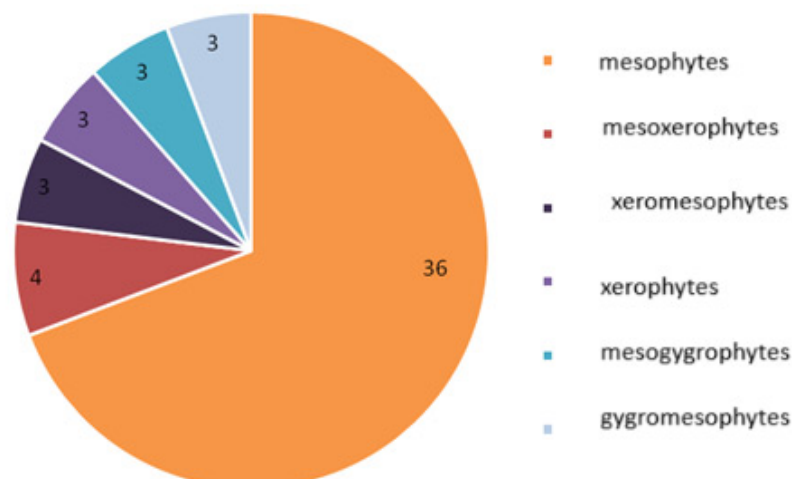


Figure 2. Quantitative ratio of fruit plant species of the Kazakh Altai in relation to the moisture factor

### Conclusions

During the analysis of 52 species of wild fruit and berry plants, both with edible and inedible fruits, in the studied territory, different degrees of their rarity were established. Three species are listed in the Red Book of Kazakhstan (2014) with the status of rarity category II: *Daphne altaica*, *Paris quadrifolia* and *Vaccinium microcarpum*. Rare species in need of protection, currently based on the results of long-term research, are *Daphne mezereum*, *Ephedra monosperma*.

Thus, the species diversity of wild fruit and berry plants in the flora of the Kazakh Altai is represented by 52 species taxa belonging to 22 genera, 12 families in the composition of forest and meadow associations. According to the complex of biological indicators, shrubs dominate in life forms — 69.2 %, in relation to the moisture factor — mesophytes, at the state level with the status of rarity category II, 3 species are protected.

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## Қазақстан Алтайының табиғи флорасының жабайы жемісті өсімдіктерінің түр алуандығы

Мақаланың мақсаты: қазақстандық Алтайдың флорасында жабайы жемісті-жидекті өсімдіктердің қазіргі заманғы түрлік әртүрлілігін анықтау және оларды биологиялық көрсеткіштер кешені бойынша саралау. Қазақстандық Алтайдың тамырлы өсімдіктерінің биоалуантүрлілігін зерттеу нәтижесінде маршруттық-барлау әдісін пайдалана отырып, оның аумағында 22 тұқымдасқа, 12 туыстасқа жататын жемісті және жидекті өсімдіктердің 52 түрі өсетіні анықталды. Түр таксондарының ең көп саны 3 туыстаста бар. Атап айтсақ, *Rosaceae*, *Caprifoliaceae*, *Grossulariaceae*, бұларда 29 түр шоғырланған,

бұл жалпы санның 55,77 %-ын құрайды. Жемісті және жидекті түрлері бар өсімдіктер қауымдастығы арасында орманды (26 %) және шалғынды ассоциациялар (23 %) басым орын алады, сонымен қатар аймақтағы елдімекендердің қараусыз қалған бақша учаскелерінде *Solanum dulcamara* және *S. nigrum* бар синантропты фитоценоздар анықталды. 7 әкелінген жемісті-жидекті түрлердің өсуі айқындалды, олар: *Alkekengi officinarum*, *Berberis vulgaris*, *Malus baccata*, *Ribes aureum*, *Sambucus racemosa*, *Sorbus aucuparia*, *Symphoricarpos albus*, оның ішінде тек *Malus baccata* өз қауымдастықтарын құрған. Тіршілік формалары бойынша жемісті-жидекті түрлер ағашты, бұталы, тоғайлы, жартылай бұталы, шөптесін көпжылдықтар түрінде кездеседі. Бұталар басым, яғни 36 түр (69,2 %). Ылғалдандыру факторына қатысты анықталған түрлер 6 экологиялық топқа бөлінеді, бұл ретте мезофиттер басым, 36 түр (69,2 %). Қазіргі уақытта мемлекеттік деңгейде жемісті-жидекті түрлердің 3 түрі қорғалады: *Daphne altaica*, *Paris quadrifolia* және *Vaccinium microcarpum*, олар Қазақстанның Қызыл кітабына енгізілген, II сиректілік санаты бар.

*Кілт сөздер:* тіршілік формасы, енгізілген түрлер, Қазақстан Алтайы, орналасқан жері, жеміс-жидекті өсімдік түрлері, экологиялық топтар.

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## Видовое разнообразие диких плодовых растений природной флоры Казахстанского Алтая

Цель данной работы — выявление во флоре Казахстанского Алтая современного видового разнообразия дикорастущих плодово-ягодных растений и ранжирование их по комплексу биологических показателей. В результате изучения биоразнообразия сосудистых растений Казахстанского Алтая, используя маршрутно-рекогносцировочный метод, установлено произрастание на его территории 52 видов плодовых и ягодных растений, относящихся к 22 родам, 12 семействам. Наибольшим числом видовых таксонов представлены 3 семейства: *Rosaceae*, *Caprifoliaceae*, *Grossulariaceae*, в которых сосредоточено 29 видов, что составляет 55,77 % от общего числа. Среди растительных сообществ с участием плодовых и ягодных видов доминирующее положение занимают лесные (26 %) и луговые ассоциации (23 %), также установлены синантропные фитоценозы с участием *Solanum dulcamara* и *S. nigrum* на заброшенных садовых участках населенных пунктов региона. Выявлено произрастание 7 заносных плодовых и ягодных видов: *Alkekengi officinarum*, *Berberis vulgaris*, *Malus baccata*, *Ribes aureum*, *Sambucus racemosa*, *Sorbus aucuparia*, *Symphoricarpos albus*, из которых только *Malus baccata* образовал собственные сообщества. По жизненным формам плодовые и ягодные виды представлены деревьями, кустарниками, кустарничками, полукустарниками, травянистыми многолетниками. Доминируют кустарники — 36 видов (69,2 %). По отношению к фактору увлажнения выявленные виды ранжированы по 6 экологическим группам, где господствуют мезофиты — 36 видов (69,2 %). Из плодовых и ягодных видов на государственном уровне в настоящее время охраняются 3 вида: *Daphne altaica*, *Paris quadrifolia* и *Vaccinium microcarpum*, включенные в Красную книгу Казахстана, со статусом категории редкости II.

*Ключевые слова:* жизненные формы, заносные виды, Казахстанский Алтай, местонахождение, плодово-ягодные виды растений, экологические группы.

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