Pak. J. Bot., 58(2): 539-545, February 2026.

ARTICLE | DOI: http://dx.doi.org/10.30848/PJB2026-2(18)

RARE, ENDEMIC AND WILD SPECIES OF THE GENUS *RIBES* IN CENTRAL ASIA AND KAZAKHSTAN: CURRENT STATUS AND CONSERVATION PROSPECTS (REVIEW)

INDIRA SAMATOVA[1], ZARINA INELOVA[1*], ALMAGUL KAKIMZHANOVA[2], BUHO HOSHINO[3], YELENA ZAPARINA[1] AND MENGTAY AITZHAN[1]

[1]Al-Farabi Kazakh National University, Almaty, Kazakhstan
[2]National Center of Biotechnology, Astana, Kazakhstan
[3]Rakuno Gakuen University, Ebetsu, Japan

*Corresponding author's email: zarina.inelova@kaznu.edu.kz

Abstract

This review focuses on rare, endemic, and wild species of the genus *Ribes* in Central Asia and Kazakhstan. It highlights species listed in national and international Red Lists and discusses the primary threats they face, such as habitat degradation, climate change, and anthropogenic pressure. The review provides details on species distribution, ecological characteristics, and altitudinal ranges, emphasizing the high degree of habitat fragmentation and narrow ecological specialization of most species. The importance of regional monitoring, comprehensive floristic studies, and genetic research is underscored. The review also explores current conservation techniques, including seed and vegetative propagation, *In vitro* micropropagation and cryopreservation. The limited development of protocols for most rare *Ribes* species is identified as a significant barrier to effective conservation efforts. It also considers integrated conservation strategies that combine *In situ*, *Ex situ*, and *quasi In situ* approaches. Emphasis is placed on the need for international cooperation, the creation of botanical databases, and the incorporation of biotechnological methods into conservation practices. Preserving *Ribes* biodiversity requires a multifaceted approach, combining scientific, technological, and legal solutions to ensure the long-term survival of these species.

Key words: *Ribes*; Central Asia; Rare species; Endemics; Plant conservation; Biodiversity; Micropropagation; Cryopreservation

Introduction

Biodiversity plays a fundamental role in maintaining the sustainability of ecosystems and preserving the natural balance. Plant communities provide important ecosystem services, including climate regulation, maintenance of the hydrological regime, preservation of soil fertility and carbon balance (Elisha & Felix, 2020). However, in recent decades, anthropogenic factors, including urbanization, agricultural intensification, pollution and climate change, have led to significant decline in the numbers of many plant species (Palombo, 2021).

Even by the lowest estimates, the rate of plant extinction is significantly higher than the natural rate, which confirms the need for urgent measures to preserve those (Humphreys *et al.*, 2019). According to the International Union for Conservation of Nature (IUCN), in 2024, of the 46,337 species listed as threatened with extinction on the Red List, more than 58% are flowering plants. The situation is particularly critical among woody plants: of the 47,000 species assessed, more than 16,000 (≈38%) are threatened with extinction (Botanic Gardens Conservation International, 2024).

The escalating biodiversity crisis, evidenced by the increasing number of endangered plant species, highlights the need for in-depth studies of rare and endemic taxa, especially in regions with high data uncertainty. One such region is Central Asia, where climate change, habitat destruction and human impacts are putting many species at risk of extinction (Baymetov, 2012; Habibullah *et al.*, 2022).

Genus *Ribes* L. (family *Grossulariaceae)* includes about 160 species, distributed mainly in temperate and cold regions of the Northern Hemisphere (Cortez & Gonzalez de Mejia, 2019). These plants play an important role in ecosystems, providing food resources for animals, participating in soil-forming processes and carbon balance. In addition, many species of the genus *Ribes* are of economic importance, being used in the food, pharmaceutical and ornamental industries (Hummer & Dale, 2010; Da Silva Pinto *et al*., 2010; Sun *et al*., 2021). However, in Central Asia there are rare, endemic and wild representatives of the genus *Ribes*, which are distinguished by a narrow ecological amplitude and limited ranges (Eastwood *et al*., 2009). Unlike widespread species, they are most vulnerable to external factors. Despite their potential value, the degree of study of these species remains insufficient, which makes it difficult to develop effective measures for their conservation.

The objective of this review is to analyze the current state of research on the phytogeography, ecology, and conservation methods of rare, endemic, and wild *Ribes* in Central Asia and Kazakhstan. The paper examines the main threats to their existence, assesses gaps in knowledge and suggests promising areas for further research.

Received: 22-06-2025 | Revised: 10-09-2025 | Accepted: 15-09-2025 | Online: 11-11-2025

Method and Materials

This review article is based on the analysis of recent scientific literature regarding the conservation of rare, endemic, and wild species of the *Ribes* genus under climate change conditions. The literature search was carried out through a systematic review of international and regional databases, including Scopus, Web of Science, PubMed, eLibrary, and Google Scholar.

The selection criteria for the sources included:

- Relevance of publications (primarily from 2000 to 2024);
- Thematic focus (genetic resource conservation, eco-geographical characteristics, biotechnological methods);
- Availability of data on *Ribes* species found in Central Asia and neighboring regions.

Both original research articles and review papers, reports from international organizations, and dissertations were incorporated into the analysis. Emphasis was placed on publications discussing *In situ* and *Ex situ* conservation methods, as well as the application of *In vitro* techniques and cryopreservation.

Information was organized using thematic and geographical categories. National Red Books and floristic surveys from Kazakhstan, Uzbekistan, Kyrgyzstan, and Tajikistan were also reviewed.

Geographic information systems (GIS) methods were used to construct the map. Cartographic visualization was performed in QGIS, which made it possible to display documented locations of the studied species and clearly present their distribution in the region.

Results and Discussion

As part of the commitments made by Central Asian countries under the UN Convention on Biological Diversity, special attention is paid to the inventory and assessment of rare and endemic species. However, research on the phytogeography and conservation of valuable *Ribes* species in the region remains limited and requires further investigation. The genus *Ribes* L. belongs to the family Grossulariaceae (Fedorov *et al*., 1980). It is divided into two subgenera: *Ribes* (currants) and *Grossularia* (gooseberries), although molecular phylogenetic studies confirm the monophyly of the latter and its nesting in *Ribes* (Weigend *et al*., 2002). Biogeographic analysis indicates a western North American origin of the subgenus *Grossularia*, followed by its dispersion into Asia (Schultheis & Donoghue, 2004).

Several rare and endemic species of *Ribes* have been identified in Central Asia, listed in the Red Data Books of individual countries and the International Union for Conservation of Nature (IUCN) Red List, indicating the threats to their survival. Despite these efforts, the importance of detailed studies and the development of effective conservation methods for these species under changing climatic conditions remains a critical topic for further research.

Ribes malvifolium Pojark. is a critically endangered species (CR) according to the IUCN classification, occurring only in two localities in Tajikistan and Uzbekistan. The main threats include fruit collection and livestock grazing, which leads to population degradation (Red Book of Uzbekistan, 2019).

Ribes janczewskii Pojark. - a rare species found in Kazakhstan and the Gorno-Badakhshan region of Tajikistan. It is included in the national Red Books (Red Book of Kazakhstan, 2014).

Ribes melananthus Boiss. & Hohen. - endemic to the Central Kopetdag (Turkmenistan), restricted at altitudes of 2600-2800 m. The species is listed in the Red Book of Turkmenistan and is protected in the Kopetdag State Nature Reserve, but is not included in the global IUCN assessment (Red Book of Turkmenistan, 2011) (Table 1).

Analysis of the presented data allows us to identify key regions of distribution of rare and endemic species of *Ribes.* To visualize the spatial distribution of these species, a map was compiled reflecting their ranges and possible threats.

Figure 1 illustrates the geographic distribution of selected species of the genus *Ribes* in Central Asia based on documented locations and estimated coordinates. The following species are included in the study: *Ribes janczewskii* Pojark, *R. meyeri* Maxim, *R. malvifolium* Pojark., *R. atropurpureum* Kom., *R. petraeum* Wulfen and *R. nigrum* L. Geographic data were collected from literary sources, herbarium materials and field observations, which allowed us to create a cartographic visualization of their ranges.

The map covers the territories of Kazakhstan, Kyrgyzstan, Uzbekistan and Tajikistan, where the locations of the species under study are marked. The analysis showed that most representatives of the *Ribes genus* are confined to mountain and foothill ecosystems, which indicates their ecological and cenotic specialization and adaptation to certain orographic and climatic conditions.

Cartographic data confirm a high degree of habitat fragmentation, which emphasizes the need for a detailed study of the factors affecting the abundance of species. For effective protection, it is necessary to take into account altitudinal zonation, soil conditions and the degree of anthropogenic pressure. Lack of information on the phytogeography and genetic diversity of species limits the possibilities of monitoring and developing conservation strategies. Conducting comprehensive studies, including cartographic analysis, molecular studies and field observations, will allow the development of effective measures to protect populations.

Rare and endemic species of *Ribes* are subject to a dual threat, the intensifying impacts of climate change and the lack of comprehensive botanical data combined with insufficient monitoring efforts. Central Asia, recognized as one of the most climate-sensitive regions globally, is experiencing an accelerated rise in average annual temperatures compared to global trends (Narzullaev, 2024). Particularly is the increase in the number of hot days (from 2-3 in the 1980s to 15-20 in the 2010s), which provokes increased aridization and reduces water availability - a key factor in the survival of mesophytic and subalpine species, which include a number of representatives of the genus *Ribes*.

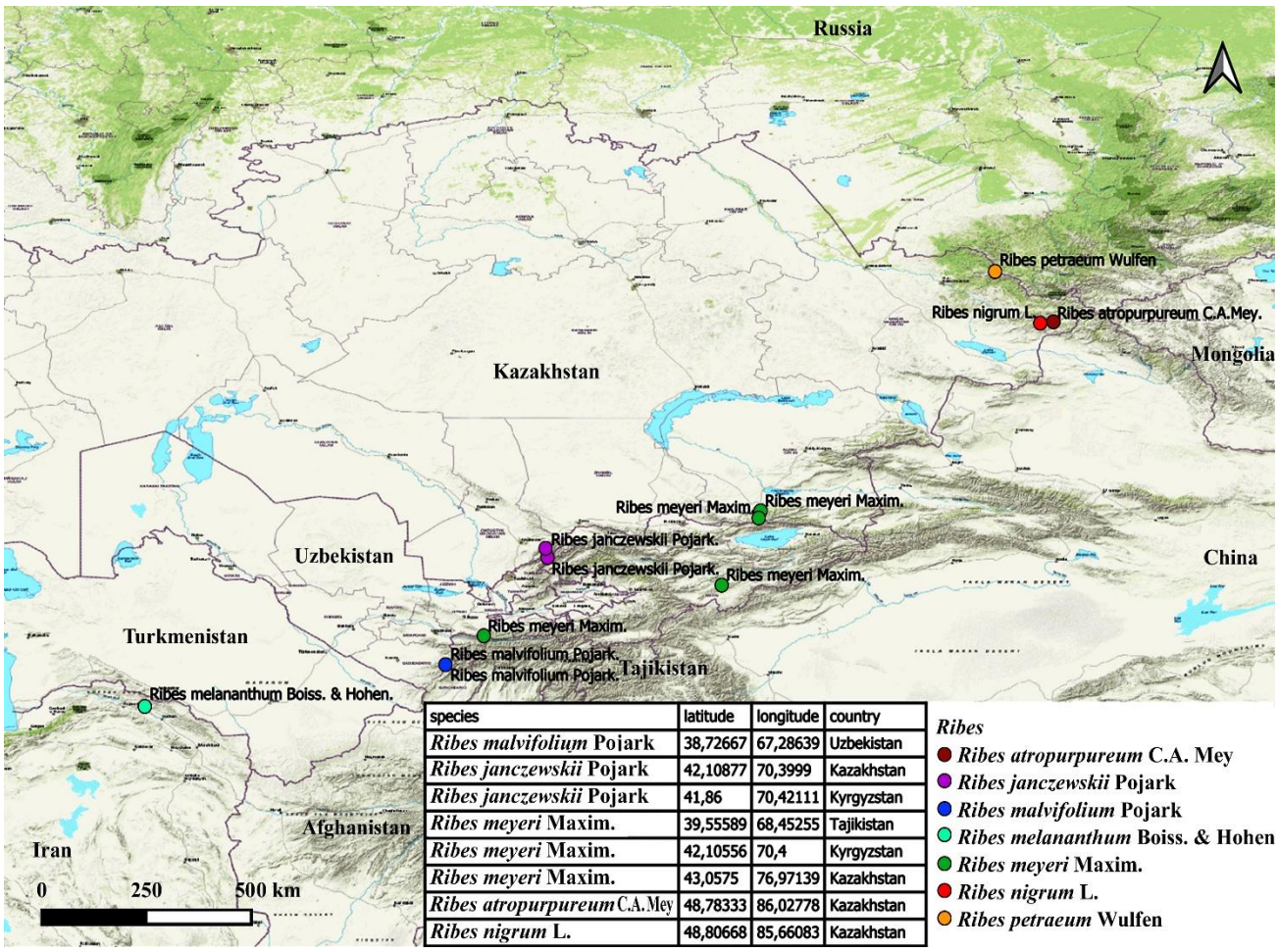
The study by Li *et al*., (2016), based on NDVI analysis and meteorological data, showed that vegetation degradation in Central Asia was primarily associated with summer moisture deficits - a combination of decreased precipitation and increased potential evapotranspiration. Meadows and forests were found to be particularly sensitive to water stress, whereas desert vegetation exhibited less pronounced responses. Considering that the ranges of many rare *Ribes* species overlapping with forest or alpine ecosystems, this trend appears to be critical.

Table 1. Distribution, ecology and conservation status of rare, endemic and wild *Ribes* species in Central Asia.

Specie	Country	Height (m)	Environmental conditions	Status	Source
Ribes nigrum L.	Kazakhstan (Altai Botanical Garden, Ridder)	1513	Wet soils along streams, mixed forest (*Populus, Betula, Sorbus, Larix*)	Not evaluated	Vdovina *et al*., 2024
Ribes petraeum Wulfen	Kazakhstan (Ivanovsky Range, Western Altai, Eastern Kazakhstan)	1756	Under the canopy of dark coniferous forest (*Abies, Pinus, Betula*), in groups in clearings	Not evaluated	Vdovina *et al*., 2024
Ribes meyeri	Kyrgyzstan (At-Bashi Valley, Naryn region)	1500-3000	Northern slopes under the canopy of walnut and juniper forests, banks of rivers and streams, forests of *Sorbus tianschanica* and *Salix tianschanica*	EN	Shalpykov & Beyshenbekov, 2007; Imanberdieva, 2015
Ribes meyeri	Kazakhstan (Ile-Alatau State National Nature Park, Almaty region)	Not applicable	IN undergrowth spruce (*Picea schrenkiana*) and mixed forests, found With *Lonicera* spp., *Rosa albertii, Cotoneaster oliganthus, Sorbus tianschanica*	EN	Sitpayeva *et al*., 2019
Ribes meyeri	Kazakhstan (Zhongar-Alatau State National Nature Park, Zhetysu region)	900-1400	Undergrowth of the coniferous-deciduous forest belt. It is found With *Viburnum opulus, Rosa* spp., *Lonicera* spp., *Cotoneaster melanocarpus, Prunus spinosa, Rubus* spp. On forest edges and under the forest canopy	EN	Tleppaeva & Kadyrbekov, 2022
Ribes malvifolium Pojark.	Tajikistan	Not applicable	not applicable	CR	Safarov *et al*., 2019
Ribes malvifolium Pojark.	Uzbekistan	Not applicable	not applicable	CR	Khasanov *et al*., 2012
Ribes janczewskii Pojark.	Kazakhstan (Sairam -Ugam State National Nature Park, Turkestan region)	2351	Wooded mountain slopes, shrub communities	EN	Nurtaza *et al*., 2023
Ribes atropurpureum	Kazakhstan (Western Altai, Eastern Kazakhstan)	1569	Currant-honeysuckle phytocenosis in a dark coniferous forest (*Abies sibirica)* with a dense shrub layer (*Lonicera altaica, spirea chamaedrifolia)*. The soil is humus, with small pebbles. It is found in clearings with *Sorbus sibirica* and singular *Sambucus sibirica*	Not applicable	Sumbembaev & Danilova, 2016.
Ribes melananthus Boiss. & Hohen.	Turkmenistan (Kopetdag State Nature Reserve, Ashgabat region)	2600-2800	It lives in mountain forests, thickets of bushes and meadow steppes, and is often found near water sources and along the banks of mountain rivers	EN	Akmuradov, 2024

These species are susceptible to anthropogenic impacts including fruit harvesting, habitat degradation and climate change. Table 1 presents systematic information on the distribution, ecology and conservation status of rare, endemic and wild *Ribes* species in Central Asia.

Note: CR - critically endangered species; EN - species threatened with extinction



species	latitude	longitude	country
Ribes malvifolium Pojark	38,72667	67,28639	Uzbekistan
Ribes janczewskii Pojark	42,10877	70,3999	Kazakhstan
Ribes janczewskii Pojark	41,86	70,42111	Kyrgyzstan
Ribes meyeri Maxim.	39,55589	68,45255	Tajikistan
Ribes meyeri Maxim.	42,10556	70,4	Kyrgyzstan
Ribes meyeri Maxim.	43,0575	76,97139	Kazakhstan
Ribes atropurpureum C.A.Mey	48,78333	86,02778	Kazakhstan
Ribes nigrum L.	48,80668	85,66083	Kazakhstan

Fig. 1. Habitat of wild, rare and endemic species of the genus *Ribes* in Central Asia and Kazakhstan.

An additional stress factor is forest fires, the frequency and intensity of which are increasing against the backdrop of warming, as demonstrated in models by Li *et al*., (2020). However, it should be noted that these projections are based on a single scenario (HadGEM2-ES), which limits their applicability in assessing the full range of climate impacts. Moreover, the response of specific *Ribes* taxa to extreme climatic events remains largely unexplored, creating a gap in the development of adaptive conservation strategies.

These environmental threats are exacerbated by the lack of reliable, up-to-date and accessible floristic information. As emphasized by Zhang *et al*., (2020), data on the flora of Central Asia are fragmentary, often outdated and available only in printed form in local languages. The lack of digital botanical databases and weak coordination between countries in the region make it difficult to monitor the status of rare species and adapt them to changing conditions.

Given the threats described above, it is clear that effective conservation of rare *Ribes species* requires an integrated and regionally adapted approach. An important contribution to this area is provided by Volis (2023), who presented a strategy combining *In situ, Ex situ* and *quasi In situ* methods as interrelated elements for effective vegetation conservation.

Seed propagation is traditionally considered a simple and accessible method of preserving plant material (Hay & Probert, 2013; Walters & Pence, 2021). Although this method is widely used worldwide for rare and endemic *Ribes* species, for some species, especially those with a limited range or complex reproductive biology, seed conservation may not guarantee accurate reproduction of the original genotype. One of the main problems is the presence of recalcitrant seeds in a number of *Ribes* species, which are sensitive to drying and low storage temperatures (Engelmann, 2011). These seeds may lose their viability under inappropriate storage conditions, making seed propagation unreliable for long-term conservation. Even with normal seed germination, seed propagation does not always ensure the precise preservation of the unique gene pool. This is especially true for highly isolated populations or species with a high level of hybridization (Anderson *et al*., 2002). Genetic variability observed in the offspring can complicate the tasks of protecting and preserving the original genotypes of rare and endemic *Ribes* species (Pence, 2011). Thus, seeds do not always accurately preserve the gene pool, which requires the use of more effective conservation methods.

For more reliable conservation of rare *Ribes* species, vegetative propagation methods are of particular importance (Hummer & Dale, 2010; Benelli *et al*., 2022; Tarraf & De Carlo, 2024). One of these methods is micropropagation *In vitro,* which allows cloning plants while preserving all morphological and genetic characteristics (Vujović *et al*., 2011; Dziedzic & Jagła, 2013; Ryago, 2023; Ryago *et al*., 2025). This ensures not only the preservation of a unique gene pool, but also allows for the rapid propagation of valuable material. The method is also effective in improving the health of plants against viruses and other diseases, and enables long-term storage

at low temperatures under controlled conditions. Micropropagation has advantages over seed propagation because it allows for more accurate preservation of the original genotypes, avoiding the genetic variability that may arise with seed propagation (Chokheli, 2020). However, for this method to be successfully applied, the protocols must be adapted to each specific species. For some *Ribes* species, such as blackcurrant (*R. nigrum)* and Meyer's currant (*R. meyeri)*, micropropagation protocols have already been developed that ensure efficient propagation in laboratory conditions (Kanaev *et al*., 2019; Karipbaeva *et al.*, 2020; Khromova *et al*., 2021; Khromova *et al.*, 2024). However, for other rare and endemic species, protocols have not yet been developed, and additional research is required to adapt the methods to their specific biological characteristics.

Cryopreservation is one of the most promising methods for long-term conservation of rare *Ribes* species by encapsulating plant material in liquid nitrogen at -196°C (Reed, 2008; Matsumoto, 2017; Benelli, 2021; Nagel *et al.*, 2024). This approach ensures reliable preservation of specimens without changes and risk of contamination, which is essential for preserving the genetic diversity of rare and endemic species. Studies on cryopreservation of *Ribes* species and cultivars showed that dormant buds could be successfully preserved by deep freezing in liquid nitrogen (Green & Grout, 2010; Rantala *et al*., 2019; Jenderek *et al*., 2021). One of the first examples was the study by Sakai & Nishiyama (1978), which demonstrated the viability of plants shoots after cryopreservation (Reed, 2008). Despite the effectiveness of this approach, its use in gene banks remains limited. According to Zimnoch-Guzowska *et al*., (2022), by 2022, about 10,000 plant samples had been cryopreserved worldwide, mainly from *In vitro* cultures, and of the 500 European gene banks, only 20 use cryogenic temperatures to store plant germplasm (Zimnoch-Guzowska *et al.*, 2022).

However, for most of the species considered in our study, such cryopreservation protocols have not yet been developed, requiring further research and experiments to create effective methodologies. Moreover, although cryopreservation of dormant buds is effective, but it has its limitations. For example, collecting buds in field conditions, especially for rare and protected species, is a labor-intensive process, as it requires strict adherence to time frames and storage conditions. It is also important to note that the amount of material available for cryopreservation is limited, which complicates the widespread application of this method for rare species.

Nevertheless, cryopreservation is considered as a necessary and promising method in the system of complex gene pool preservation. This approach provides not only safe and cost-effective long-term storage, but also the creation of duplicate reserves for field collections, reference collections for allelic diversity, as well as potential sources of new genetic variations (Kalaiselvi *et al*., 2017). Successful cryopreservation protocols have already been developed for a number of *Ribes* species, including blackcurrant (*R. nigrum)* (Kovalchuk & Turdiev, 2010; Knyazeva *et al.*, 2020; Rantala *et al*., 2021; Gavrilenko *et al*., 2023). However, for most of the species considered in our study, appropriate protocols have not yet been developed.

Conclusion

In conclusion, conservation of rare and endemic *Ribes* species in Central Asia and Kazakhstan requires an integrated approach, including both traditional and innovative conservation methods. Despite some successful protocols for individual species, such as blackcurrant, most local *Ribes* species, subject to threats such as climate change and habitat loss, require the development of individual conservation strategies. Key areas should be further development and adaptation of micropropagation methods, cryopreservation and other biotechnologies for specific species, as well as the active use of *In situ* and *quasi In situ* methods to protect natural ecosystems. Particular attention should be paid to improving population monitoring and creating conditions for ecosystem restoration, which will ensure sustainable conservation of biodiversity in the face of global change.

References

Akmuradov, A.G. 2024. Glava 1. Nauchnyy analiz endemichnye klyuchevye vidy lekarstvennoy flory Kopetdagskogo gosudarstvennogo prirodnogo zapovednika [Chapter 1. Scientific analysis of endemic key medicinal plant species in the Kopetdag State Nature Reserve]. In: (Ed.): Epkhiyeva, M.K., *Progressivnye nauchnye issledovaniya - osnova sovremennoy innovatsionnoy doktriny: Monografiya* (p. 5). Ufa: NITS AETERNA, MTsII OMEGA SAINS. [In Russian].

Anderson, G.J., S.D. Johnson, P.R. Neal and G. Bernardello. 2002. Reproductive biology and plant systematics: The growth of a symbiotic association. *Taxon*, 51(4): 637-653.

Baymetov, K.I. 2012. Diversity, distribution, and conservation of target fruit crops in Central Asian republics. Proceedings of the International Scientific and Practical Conference "*Conservation and Sustainable Use of Biodiversity of Fruit Crops and Wild Fruit Species*", 52-55.

Benelli, C. 2021. Plant cryopreservation: A look at the present and the future. *Plants*, 10(12): 2744.

Benelli, C., W. Tarraf, T. Izgu and A. De Carlo. 2022. *In vitro* conservation through slow growth storage technique of fruit species: An overview of the last 10 years. *Plants*, 11(23): 3188.

Botanic Gardens Conservation International (BGCI). 2024.

Chokheli, V.A., P.A. Dmitriev, V.D. Rajput, S.D. Bakulin, A.S. Azarov and T.V. Varduni. 2020. Recent development in micropropagation techniques for rare plant species. *Plants*, 9(12): 1733.

Convention on Biological Diversity (CBD). n.d. https://www.cbd.int/

Cortez, R.E. and E. Gonzalez de Mejia. 2019. Blackcurrants (*Ribes nigrum*): A review on chemistry, processing, and health benefits. *J. Food Sci.*, 84 (9): 2387-2401.

Da Silva Pinto, M., Y.I. Kwon, E. Apostolidis, F.M. Lajolo, M.I. Genovese and K. Shetty. 2010. Evaluation of red currants (*Ribes rubrum* L.), black currants (*Ribes nigrum* L.), red and green gooseberries (*Ribes uva-crispa*) for potential management of type 2 diabetes and hypertension using *In vitro* models. *J. Food Biochem.*, 34(3): 639-660.

Dziedzic, E. and J. Jagła. 2013. Micropropagation of Rubus and Ribes spp. *Protocols for Micropropagation of Selected Economically-Important Horticultural Plants*: 149-160.

Eastwood, A., G. Lazkov and A.C. Newton. 2009. The red list of trees of Central Asia. *Cambridge: Fauna & Flora International*, 8-21.

Elisha, O.D. and M.J. Felix. 2020. The loss of biodiversity and ecosystems: A threat to the functioning of our planet, economy, and human society. *Int. J. Econ. Environ. Develop. Soc.*, 1(1): 30-44.

Engelmann, F. 2011. Use of biotechnologies for the conservation of plant biodiversity. *In Vitro Cell. Develop. Biol. Plant*, 47: 5-16.

Fedorov, A.A., A.L. Takhtajan and A.L. Kursanov. 1980. Zhizn rastenii: v 6 t. T. 5. Moscow: Prosveshchenie. [In Russian].

Gavrilenko, T.A., S.E. Dunaeva, O.A. Tikhonova and I.G. Chukhina. 2023. New approaches to the registration and conservation of domestic varieties of berry crops in the VIR genebank: The case of raspberry and black currant. *Biotechnol. Plant Breed.*, 5(4): 24-38.

Green, J. and B. Grout. 2010. Direct cryopreservation of winter buds of nine cultivars of blackcurrant (*Ribes nigrum* L.). *Cryo Lett.*, 31(4): 341-346.

Habibullah, S., B.H. Din, S.H. Tan, S.F. Zaini, R. Tahir, R. Seneviratne and N. Nayan. 2022. Impact of climate change on biodiversity loss: Global evidence. *Environ. Sci. Pollut. Res.*, 29: 1073-1086.

Hay, F.R. and R.J. Probert. 2013. Advances in seed conservation of wild plant species: a review of recent research. *Conser. Physiol.*, 1(1): cot030.

Hummer, K.E. and A. Dale. 2010. Horticulture of Ribes. *Forest Pathol.*, 40(3-4): 251-263.

Humphreys, A.M., R. Govaerts, S.Z. Ficinski, E. Lughadha and M.W. Vorontsova. 2019. Global dataset shows geography and life form predict modern plant extinction and rediscovery. *Nature Ecol. Evol.*, 3: 1043-1047.

Imanberdieva, N. 2015. Flora and plant formations distributed in At-Bashy Valleys-Internal Tien Shan in Kyrgyzstan and interactions with climate. *Climate Change Impacts on High-Altitude Ecosystems*, 569-590.

International Union for Conservation of Nature (IUCN). 2024.

Jenderek, M.M., K.M. Yeater, B.D. Ambruzs, J.M. Bushakra and K.E. Hummer. 2021. Cryopreservation of several *Ribes* species by dormant winter buds. *Sci. Hort.*, 289: 110496.

Kalaiselvi, R., M. Rajasekar and S. Gomathi. 2017. Cryopreservation of plant materials-a review. *Int. J. Curr. Sci.*, 5(5): 560-564.

Kanaev, A.T., A. Kambarova, R. Satymbekov and R.K. Karipbaeva. 2019. Application of microclonal propagation method for Ribes meyeri in Kazakhstan. *Ustoichivoe Razvitie Territoriy: Teoriya i Praktika*, 131.

Karipbaeva, R.K., A.T. Kanaev, M.E. Ismailova and A.B. Khani. 2020. Adaptation of Ribes meyeri regenerants to *Ex vitro* conditions. *Ustoichivoe Razvitie Territoriy: Teoriya i Praktika: Materialy Mezhdunarodnoi Nauchno-Prakticheskoi Konferentsii* (Sibay, November 19-21, 2020): 159-161. Sibayskiy Informatsionnyy Tsentr.

Khasanov, F.O., E.A. Shreder and K.S. Todjibaev. 2012. Wild relatives of fruit crops in Uzbekistan.

Khromova, T.M., L.V. Tashmatova and O.V. Matsneva. 2024. Application of various growth regulators in clonal micropropagation of black currant (*Ribes nigrum* L.). *Vestnik Rossiyskoy Sel'skokhozyaystvennoy Nauki*, (1): 30-34.

Khromova, T.M., L.V. Tashmatova, O.V. Matsneva and V.V. Shakhov. 2021. Influence of climatic conditions of the introduction period and varietal characteristics of black currant (*Ribes nigrum* L.) on the effectiveness of culture initiation *In vitro*. *BIO Web of Conferences*, 36: 04010.

Knyazeva, I.V., V.N. Sorokopudov and O.A. Sorokopudova. 2020. Elements of optimization of the *In vitro* preservation technology for black currant. *Vestnik Krasnoyarskogo Gosudarstvennogo Agrarnogo Universiteta*, (6): 48-55.

Kovalchuk, I.Y. and T.T. Turdiev. 2010. Optimization of cryopreservation methods for black currant (*Ribes nigrum* L.) germplasm. *Biotekhnologiya. Teoriya i Praktika*, (2): 54-61.

Li, W., K.S. Tojibaev, H. Hisoriev, K.F. Shomurodov, M. Luo, Y. Feng, K. Ma and K. Ma. 2020. Mapping Asia Plants: Current status of floristic information for Central Asian flora. *Global Ecol. Conser.*, 24: e01220.

Matsumoto, T. 2017. Cryopreservation of plant genetic resources: Conventional and new methods. *Rev. Agri. Sci.*, 5: 13-20.

Nagel, M., V. Pence, D. Ballesteros, M. Lambardi, E. Popova and B. Panis. 2024. Plant cryopreservation: Principles, applications, and challenges of banking plant diversity at ultralow temperatures. *Ann. Rev. Plant Biol.*, 75.

Narzullaev, K.S. 2024. Osnovnye napravleniya vozdeystviya izmeneniya klimata v Tsentral'noy Azii [Main directions of climate change impacts in Central Asia]. *ORIENS*, (2). Retrieved from https://cyberleninka.ru/article/n/osnovnye-napravleniya-vozdeystviya-izmeneniya-klimata-v-tsentralnoy-azii (accessed April 4, 2025). [In Russian].

Nurtaza, A.S., D.A. Dyusembekova, S.S. Islamova, I.N. Samatova, A.T. Umirzakova and A.A. Kakimzhanova. 2023. Optimizatsiya usloviy mikroklonal'nogo razmnozheniya i srednesrochnogo khraneniya *In vitro* redkogo vida smorodiny Yanchevskogo dlya sokhraneniya [Optimization of microclonal propagation and medium-term *In vitro* storage conditions of the rare Ribes yanchevskyi species for conservation]. *Vestnik Karagandinskogo universiteta. Seriya biologii, meditsiny i geografii*, 111(3): 125-137. [In Russian].

Palombo, M.R. 2021. Thinking about the biodiversity loss in this changing world. *Geosciences*, 11: 370.

Pence, V.C. 2011. Evaluating costs for the *In vitro* propagation and preservation of endangered plants. *In Vitro Cell. Develop. Biol. Plant*, 47: 176-187.

Rantala, S., J. Kaseva, A. Nukari, J. Laamanen, S. Tuohimetsä and S. Karhu. 2021. Droplet vitrification technique for cryopreservation of a large diversity of blackcurrant (*Ribes nigrum* L.) cultivars. *Plant Cell, Tiss. Organ Cult*., 144 (1): 79-90.

Rantala, S., J. Kaseva, S. Karhu, M. Veteläinen, M. Uosukainen and H. Häggman. 2019. Cryopreservation of *Ribes nigrum* (L.) dormant buds: Recovery via *In vitro* culture to the field. *Plant Cell, Tiss. Organ Cult.*, 138: 109-119.

Red Book of Kazakhstan. 2014.

Red Book of Turkmenistan. 2011.

Red Book of Uzbekistan. 2019.

Reed, B.M. (Ed.). 2008. Plant Cryopreservation: A Practical Guide. New York: Springer.

Reed, B.M. 2008. Cryopreservation-practical considerations. *Plant Cryopreservation: A Practical Guide*: 3-13. New York: Springer.

Ryago, N.V. 2023. Features of micro clone reproduction of some currant representatives of the genus *Ribes* spp. *Agrarian Bull.*, 23(10): 69-80.

Ryago, N.V., T.M. Khromova and L.V. Tashmatova. 2025. Optimization of the clonal micropropagation methodology elements of red currant (*Ribes rubrum* L.) taking into account genotypic features. *Vestnik of the Russian Agricultural Science*, (1): 24-29.

Safarov, N.M., K. Khisoriev and K. Shermatov. 2019. Plant diversity in Tajikistan and the present conservation status of their rare and endangered species. *Izvestiya Akademii Nauk Respubliki Tadzhikistan*, 4: 7-20.

Sakai, A. and Y. Nishiyama. 1978. Cryopreservation of winter vegetative buds of hardy fruit trees in liquid nitrogen. *HortScience*, 13(3): 225-227.

Schultheis, L.M. and M.J. Donoghue. 2004. Molecular phylogeny and biogeography of Ribes (*Grossulariaceae*), with an emphasis on gooseberries (subg. Grossularia). *Syst. Bot.*, 29 (1): 77-96.

Shalpykov, K.T. and A.K. Beyshenbekov. 2007. Current status of wild crop relatives in Kyrgyzstan. Proceedings of the International Scientific and Practical Conference "*Conservation and Sustainable Use of Biodiversity of Fruit Crops and Wild Fruit Species*", 133-137.

Sitpayeva, G.T., G.M. Kudabayeva, L.A. Dimeyeva, N.G. Gemejiyeva and P.V. Vesselova. 2019. Crop wild relatives of Kazakhstani Tien Shan: Flora, vegetation, resources. *Plant Diver.,* https://doi.org/10.1016/j.pld.2019.10.003.

Sumbembaev, A.A. and A.N. Danilova. 2016. The primary breeding and genetic evaluation of wild fruit and berry plants in the south-western Altai mountain systems. *Central Eur. J. Bot.*, 2(1): 10-25.

Sun, Q., N. Wang, W. Xu and H. Zhou. 2021. Genus *Ribes* Linn. (*Grossulariaceae*): A comprehensive review of traditional uses, phytochemistry, pharmacology, and clinical applications. *J. Ethnopharm.*, 276: 114166.

Tarraf, W. and A. De Carlo. 2024. *In vitro* biotechnology for conservation and sustainable use of plant genetic resources. *Plants*, 13(14): 1897.

Tleppaeva, A.M. and R.H. Kadyrbekov. 2022. Jewel beetles (Coleoptera, Buprestidae) of State National Nature Park Zhongar-Alatau, Kazakhstan. *Euroasian Entomol. J.*, 21(4): 233-238.

Vdovina, T.A., O.A. Lagus, E.A. Isakova and A.A. Vinokurov. 2024. State of coenopopulations of wild berry plants in the territory of Kazakhstan Altai. *Bulletin of the Karaganda University "Biology medicine geography Series"*, 11629(4): 129-134.

Volis, S. 2023. Conservation of Central Asian plant biodiversity. *Plant Diversity Central Asia*, 2: 6-39.

Vujović, T., D. Ružić and R. Cerović. 2011. Improvement of *In vitro* micropropagation of black currant 'Čačanska Crna'. *X International Rubus and Ribes Symposium*, 94: 123-128.

Walters, C. and V.C. Pence. 2021. The unique role of seed banking and cryobiotechnologies in plant conservation. *Plants, People, Planet*, 3(1): 83-91.

Weigend, M., O. Mohr and T.J. Motley. 2002. Phylogeny and classification of the genus *Ribes* (Grossulariaceae) based on 5S-NTS sequences and morphological and anatomical data. *Botanische Jahrbücher*, 124(2): 163-182.

Zhang, Y., D. Zhang, W. Li, Y. Li, C. Zhang, K. Guan and B. Pan. 2020. Characteristics and utilization of plant diversity and resources in Central Asia. *Regional Sustain.*, 1(1): 1-10.

Zimnoch-Guzowska, E., P. Chmielarz, M.K. Wawrzyniak, B.P. Plitta-Michalak, M. Michalak, M. Pałucka and A. Mikuła. 2022. Polish cryobanks: Research and conservation of plant genetic resources. *Acta Societatis Botanicae Poloniae*, 91: 9121.