UNIVERSITY OF CENTRAL ASIA

GRADUATE SCHOOL OF DEVELOPMENT

Mountain Societies Research Institute

AGA KHAN FOUNDATION

Conservation and Restoration of Unique Local Wild Relatives of Plants Together with Communities Living in the Kulob Zone of Khatlon Region

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The Mountain Societies Research Institute (MSRI) was established in 2010 to conduct research for development with the goal to improve the well-being of mountain societies in Central Asia. MSRI is part of the Graduate School of Development, University of Central Asia. The University of Central Asia (UCA) was founded in 2000. The University of Central Asia (UCA) was founded in 2000. The Presidents of Kazakhstan, the Kyrgyz Republic, and Tajikistan, and His Highness the Aga Khan signed the International Treaty and Charter establishing this secular and private university, ratified by the respective parliaments, and registered with the United Nations.

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Annotation

The aim of the project was to study, preserve, and restore unique local wild relatives of plants together with communities living in the Kulob zone of Khatlon region. The main objects of the study were rare local genotypes of *Amygdalus bucharica* Korsh., *Ficus carica* L., *Malus sieversii* (Ledeb.) M. Roem., *Pyrus tadshikistanica* Zapr., *Pyrus korshinskyi* Litv., and *Punica granatum* L. According to the goals of the project, the following activities were carried out: 1. Organizing technical expeditions to identify and map the presence of wild relatives of fruit plants in the mountain pastures of Shamsiddin Shohin district; 2. Conservation of the genetic resources of local fruit varieties and sustainable management of wild relatives of cultivated plants through the establishment of nurseries in the project area; and 3. Transfer of technical skills in plant conservation and propagation to local communities through a capacity-building program entailing workshops involving technical experts. Upon completion of the project tasks, the following results were obtained: 1. The current state of research on the project topic and the main directions of research in this general regard in world science were established; 2. Taxonomy conservation status was studied; 3. Morphological characters were described; 4. Areas in Kulob zone of Khatlon region were mapped; 5. Characteristics of the population of local fruit trees were investigated; 6. Nurseries of fruit crops were established; 7. Recommendations for the patenting of landraces were given; and 8. Trainings on advanced horticulture practices were carried out for the local farmers.

Keywords: *Amygdalus bucharica* Korsh., *Ficus carica* L., *Malus sieversii* (Ledeb.) M. Roem., *Pyrus tadshikistanica* Zapr., *Pyrus korshinskyi* Litv., *Punica granatum* L., mapping of wild fruit plants, conservation of wild fruit plants, ethnobotany.

Introduction

Nature on Earth has provided different sources of life forms, ultimately allowing humans to survive. Primitively, humans collected all types of fruits, leaves, and roots of plants from the wild long before learning how to grow plants. Wild food plants are categorized as underutilized or neglected crops, as those species exist in the wild or are grown on a local scale with their economic potential barely explored, left largely to local and traditional uses only. Millions of people across many developing countries depend on wild resources including wild edible plants to meet their food needs, especially in periods of food crises (Patil & Wankhade, 2020). Accordingly, the selection of superior phenotypes of fruit trees and products based on criteria established by local people is a prerequisite for the domestication and conservation of future species (Gurashi et al., 2017).

The *Malus* (apple) and *Pyrus* (pear) are some of the most important fruits in the world. They are now cultivated almost everywhere, and are especially prevalent in the north temperate zone (Qian et al., 2020). Along with cultivated plants, the local population actively uses wild species, forms that are obtained from natural populations and natural hybrids between wild and domestic forms. In many places in Europe and Asia, wild species of apple and pear have been cultivated to preserve and conservate the wild populations of *Malus* and *Pyrus* species. In both *Malus* and *Pyrus,* the crops and their wild relatives are self-incompatible and fully inter-fertile, so spontaneous hybridization between tame and wild is rather common. As already noted, in new territories, introgression from native wild relatives seems to have facilitated the build-up of locally-adapted cultivars (Zohary, 1997). Thus, native species of apple and pear are very important for conservation and cultivation, as their adaptive potential, developed over long periods of time, is useful for the selection of adapted forms with a high level of yield, a large number of useful substances, and resistance to diseases and pests. These wild relatives are of global significance, as they represent an important store of genetic variety of which, to date, only a minor fraction has been studied.

Tajikistan is a small mountainous country in southern Central Asia. It borders Kyrgyzstan to the north, China to the east, Afghanistan to the south, and Uzbekistan to the west. Some 93% of the country is mountainous or hilly. Elevation ranges from 300 m above sea level (m a.s.l) to 7,495 m a.s.l, resulting in diverse soil and climatic conditions across the country (Muminjanov et al., 2015). The agricultural sector contributes about 20-22% of Tajikistan's gross domestic product and 25% of its export earnings, and provides employment for over half of the population (TajStat, 2012). Moreover, the sale of agricultural products contributes to 30-35% of the income from exports and 35-38% from taxes and levies. Thus, agriculture has great potential to stabilize economic growth, alleviate poverty, and improve food security in Tajikistan.

Tajikistan was described by N. I. Vavilov, the renowned Russian agronomist, botanist, and geneticist, as one of the centers of origin and diversity for many crop species. In Tajikistan, a vastly diverse range of fruit crops like pistachio, apricot, pear, apple, almond, walnut, fig, and pomegranate are concentrated. However, there has been a significant loss in agricultural biodiversity during recent decades due to the introduction of non-endemic species in major crops, including in horticulture. Due to little varietal improvement work being undertaken for minor or underutilized crops, there still exists substantial diversity in berries, nuts, and horticultural crops. Awareness raising by various local, regional, and international organizations about the importance of plant genetic resources has attracted the attention of policymakers, researchers, and farmers with respect to *in situ* and *ex situ* conservation and sustainable utilization of these resources.

Mountain forests and wild plant relatives of southern Tajikistan for many millennia have been used for economic purposes by humans. They have been sources of food products and raw materials for medicines for centuries. However, due to the increasing human and livestock population, wild plant resources have been over-exploited for fuelwood, fodder, and other agricultural needs to meet the increasing human demand for food. Recently, the mass migration of people from the valley floors to the mountain catchments in the Kulob zone has led to the devastation of a large tract of mountain pasture and indigenous vegetation, particularly wild relatives of food plants. These areas of pasture and wilderness, which were once the hub of important food and medicinal plants, has been converted into sloping agricultural land. Consequently, the indigenous flora of this region have drastically decreased, and many economically-important food plant species, such as wild apple tree (*Malus siversii*), Regel pear (*Pyrus regeli*), Tajik pear (*Pyrus tadshikistanica*), walnut (*Juglans regia*), Vavilov's almond (*Amygdalus vavilovii*), have declined to the point of becoming rare and are even on the verge of local extinction.

Thus, there is an urgent need for the conservation and restoration of rapidly-declining key food plants and their wild relatives in their natural habitat. In addition, efforts are required to conduct extensive surveys and identify rare wild plants, to collect the seeds of key food plant species, and to establish nurseries for further proliferation and dissemination of important plants as well as spreading technical knowledge of plant propagation and conservation among local communities to support sustainable food production systems.

The main objects of the study are the following valuable species of fruit tree: *Amygdalus bucharica* Korsh., *Ficus carica* L., *Malus sieversii* (Ledeb.) M. Roem., *Pyrus tadshikistanica* Zapr., *Pyrus korshinskyi* Litv., *Punica granatum* L.

The aims of the project were:

1. Identifying and mapping the availability of wild relatives of fruit plants in mountain pastures of Shamsiddin Shohin district in the Kulob zone of Khatlon region through organizing technical expeditions;
2. Conserving genetic resources of local fruit varieties and ensuring sustainable management of wild relatives of cultivated plants through the establishment of nurseries in the project area; and
3. Transferring technical skills on plant conservation and propagation to local communities through a capacity-building program entailing workshops and seminars in which technical experts are engaged.

1. Characteristics of the Research Site Location

The Republic of Tajikistan is located in southern Central Asia. The total length of the country's borders is approximately 3,000 km, of which 590 km is with Kyrgyzstan, 950 km is with Uzbekistan, 430 km is with the People's Republic of China, and 1,030 km is with Afghanistan. The greatest distance from west to east is approximately 700 km, and from north to south it is 350 km. The South Tajik Depression occupies the lower part of the Pamir-Alay mountain system (in some geological and geographical literature (Atlas of the Tajik SSR, 1968; Gvozdetsky, 1979), it is known as the Tajik Depression).

1.1. Natural Conditions

Relief

In southwestern Tajikistan, south of the high mountains of Gissar-Alay and west of the Pamirs, there is a relatively low area with low ridges and vast basins, often referred to as the South Tajik

Depression. The location of the ridges here is peculiar in itself: reaching their highest height in the northeast, there is a fan-shaped divergence towards the southwest, as they gradually decrease and, finally, fade into the right bank of the Pyanj and Amu-Darya Rivers. At the same time, the heights of the mountains and ridges range between 300-1,700 m (at absolute elevations of 500-2,300 m), and in the northeast they are between 2,500-4,000 m (Tajik..., 1974). Meanwhile, Kulob zone (Stanyukovich, 1982) is located in southeastern Tajikistan. To the south, the zone borders the Pyanj River, to the west the border runs along the western part of Darvaz Ridge, to the north it borders Vakhsh Ridge, and to the east it borders the Vakhsh province along Tereklitau Ridge.

Climate

The geographical position of Tajikistan, being at a great distance from any ocean, determines two main features of its climate: sharp continentality and aridity. At the same time, in terms of surface structure, Tajikistan has some of the highest mountains in Central Asia (Usakov, 1982). Due to the heterogeneity of the physical and geographical conditions within Tajikistan, it contains a number of climatic zones. According to A.A. Grigoriev and M.N. Budyko (1959), Tajikistan climatically belongs to the Anterior Asian and Central Asian regions. The average annual air temperature in the valleys of southern Tajikistan is 16–17 °*C*., while the average monthly temperature of the coldest month (January) is still above freezing (1-2°*C*). However, the air temperature can often drop to between -12° and -15 °*C*, and, in some cold years, the absolute minimum reaches between -22° and -28°*C*. Although, with more clouds in winter, the daily temperature fluctuations do not exceed 7°*C*. Precipitation falls mainly in the colder parts of the year in the form of rain and sleet making up 100-180 mm annually. Moreover, snow melts quickly, and does not thus form a permanent continuous cover. In some years, snow depth has been as high as 30–40 cm, but the highest average multi-year ten-day depth does not exceed 10 cm. At the same time, the average temperature in July, the warmest month, is 32°*C*, although the absolute maximum can reach 48°*C* (Nizhny Pyanj), while the annual absolute maximum is 42–44°*C*.

Summer is very hot and dry, and clouds are almost entirely absent, with daily temperature amplitudes reaching 17–18°*C*. In this regard, the greatest extremes are usually observed in September, when the weather is clear and hot during the day, and intense cooling occurs at night. The Kulob zone is particularly hot. During the plant growing season, in the valleys, an average of up to 5,400-5,500°*C* sums of temperatures are accumulated. As the altitude rises, the temperature drops and approaches zero at an altitude of about 3,500 m. Here, the temperature can be below the level conducive to the beginning of the active vegetation of plants for 250-300 days per year.

The duration of the frost-free period is 260 days in lowlands and up to 90 days in highlands. Meanwhile, the spring and autumn seasons, generally, last between 70 and 90 days. The effective temperature(sum of the temperature above 10°*C* per day) in valleys ranges between 250-300 days per year. In the hottest months, the absolute maximum temperature here rises to 45-47°*C*, while, in areas at 2,000 m a.s.l. or higher, it reaches a maximum of 30°C. Regarding precipitation, there is very little in summer, with most of it falling in December-February (120-270 mm) and March-May (150-440 mm). The humidity level in the area moistens the soil in the spring and early summer periods with drought usually occurring only in July. The period classified as cold is relatively short at an altitude of 400 m (around 60 days) but longer at 2,200 m and above (around 160 days). In the parts up to 600 m a.s.l., vegetative winters happen at a frequency of 60-80%. The number of days with snow cover during the cold period increases with altitude. In particular, there are 10-20 days per year of snow cover in the valleys, around 30-40 days at an altitude of 1,000-1,100 m a.s.l., and around 100 days above 2,000 m a.s.l. In addition to the duration of snow cover, the height of snow cover also increases corresponding to altitude, going from 10-15 cm in the valleys to 70-90 cm at the top (Brudnaya, 1982).

Soil

In the South Tajik Depression, there are relatively wide terraces of flat valleys and foothill plains, separated by low-to-medium mountain ridges of up to 2,000 m a.s.l. (Kerzum, Vasilchikova, 1982). In the Kulob zone, there are distinguishable soil belts: grey earth; brown mountain; meadow-steppe; and alluvial. The serozem belt is a specific natural area that is genetically related to mountain systems and owes its origin to the influence of mountains. In the valleys of southern Tajikistan, the grey earth belt is represented by one type and all its subtypes. Elsewhere, the salt marshes in the Vakhsh valley are classified as chloride and sulfate-chloride, and, in the Kulob-Parkhar valley, they are chloride-sulfate and sulfate (Kuteminsky, Leontyeva, 1966). Serozems are distributed up to a height of 1,600 m a.s.l. These are the main soils that allow for irrigated agriculture; they develop where annual precipitation exceeds 200 mm. Serozems are divided into three subtypes: light, ordinary, and dark. Brown mountain soils are also widespread in the southern parts of the country at altitudes ranging from 1,600 to 2,600 m a.s.l. Meanwhile, meadow-steppe soils occupy the upper strip of mountains at altitudes ranging from 2,800 to 3,200 m a.s.l. In addition, alluvial soils are found only along the floodplains of the Kyzylsu, Yahsu, and Pyanj Rivers (Kuteminsky, Leontieva, 1966).

1.2. Plant Communities

The vegetation in the South Tajik Depression is the most xerophytic variant of the Western-Asian type in the Pamir-Alay zone and is divided into three belts (Goncharov, 1937; Stanyukovich, 1973), described below.

1. Short-grass semi-savannas, covered with dwarf shrubs in the summer and with ephemeral plants in the winter and spring, are located at 300-900 m a.s.l. The base, which determines the vegetation of ephemeral synusia, is comprised of bulbous bluegrass and sedges (Poa bulbosa, Carex pachystilis) and ephemeral forbs (Trisetum cavanillesii, Leptaleum filifolium, certain species of Astragalus, Vulpia, etc.) and occupies the lower parts of the plains and rolling foothills at altitudes of 450-800 m a.s.l. (Sidorenko, 1961). Patches of bluegrass and sedges with saltwort Salsola turkestanica, S. carinata can also be frequently found here. Desert varieties, such as wormwood, saltwort, hammada, and calligonum, are widespread along the Vakhsh and Kafirnigan Rivers located in this belt. Sandy plains and foothills are also populated, though not as densely, with Saxaul, Circassian, and Calligonum varieties. In this territory, there are many areas dominated by annual crops, such as medusahead (Thaeniatherum asperum) and jointed goatgrass (Aegilops triuncialis, A. squarrosa, A. cylindrica). In the flood-lands of the Kafirnigan, Vakhsh, and Pyanj Rivers and others, Tugay is the most common type of vegetation, including turanga (Populus pruinosa), Russian olive (Elaeagnus angustifolia), tamarisk, and thickets of tall grass, such as reed (Phragmites communis), ravenna grass (Erianthus ravennae), and wild sugarcane (Saccharum spontaneum).

2. The ephemeral-shiblyak type of plants (sedges and bluegrass meadows with almond and pistachio trees) are found at 900-1,700 m a.s.l. Most of the territory here is covered by anthropogenic vegetation. Trees and shrubs, which were once the dominant type of vegetation here, are now almost completely gone. The prevailing ephemeral vegetation is characterized by its secondary origin, including Taeniatherum, Aegilops, barley (Hordeum spontaneum, H. bulbosum), vulpia, bromes, annual astragalus, fenugreek and ephemeroids (Anemone bucharica, A. baisunensis), and buttercup (Ranunculus leptorrhynchus). In areas of limited agricultural activity (such as in the mountains of Terikli-Tau, Aruk-Tau, and Ak-Tau), as well as on steep and gentle slopes, preserved natural vegetation, including pistachio, almond, and redbud trees, can be found (Sidorenko, 1961; Stanyukovich, 1973).

3. The steppes of juniper and rosarium as well as some deciduous forests are located at 1,700-2,300 m a.s.l. Small mountain ranges found in this area do not reach high altitudes with very few exceeding 2,000 m a.s.l. at any point. As a result, areas of juniper and rosarium are fragmented and spread across the territory. Some juniper trees can be found at altitudes of 1,000-1,100 m a.s.l. (the mountains of Khodja-Mumin, and the Sanglokh and Sarsarak Ridges). At altitudes of 1,300-1,400 m a.s.l., juniper mingles with pistachio (on the Sarsarak and Gazimalik Ridges), and starting at an altitude of 1,800 m a.s.l, juniper forests become denser (0.7-0.8 m2), hosting in their canopy mesophilic plants, such as Silene wallichiana, Ostrowskia magnifica, Petilium eduardi, and Polygonatum sewertzovi. The places where juniper trees have been cut down on the territory here have either been taken over by rosarium (Rosa kokanica) or become fallow land covered in orchard grass. Young fallows with Hordeum bulbosum – Aegilops triuncialis are widespread at altitudes of 1,600-2,000 m a.s.l. in the northern part of Dangarin district. Meanwhile, Caragana turkestanica grows sparsely along the eastern slope of Mount Sanglokh (Sidorenko, 1961).

2. The Current State of Research

Cultivation of fruit crops began earlier than other plants. Indeed, some of the earliest information about fruit crops, including representatives in Central Asia, can be found in the works of Ibn Sina (Avicenna) in the 11th century. Studies related to Tajikistan, including plants, started at the end of the 19th century and the beginning of the 20th century. Meanwhile, Alexander Liman made the first recorded expeditions to Tajikistan, including the regions of Bukhara and the mountainous Zeravshan. This was the first time he described wild and cultivated pear species in his scientific works (*Pyrus regeli*) (Helmersen, 1852). In addition, between 1869 and 1871, the Turkestan Scientific Expedition of the Society of Natural Science Lover's Societies, Anthropology and Ethnography at Moscow University was organized, while botanical studies were also carried out by A.P. Fedchenko and O.A. Fedchenko. For the first time, grafts from the Nashputa and Amrud pear were noted (varieties of *Pyrus tadshikistanica*) (A.P. Fedchenko, 1870). From 1882 to 1884, botanical expeditions to the central regions of Tajikistan as well to Shugnan province were organized by A.E. Regel, after which a wide diversity of wild fruit trees were described and the importance of studying them as centers of origin of cultivated plants was also highlighted in scientific papers (Regel, 1884). At the end of the 19th century, botanical research in Tajikistan was continued by V.L. Komarov, S.I. Korzhinsky, and V.I. Lipsky. In the work of V.L. Komarov, the main belts of woody vegetation were described, and the belt-zonal confinement of apple and pear trees was discussed (Komarov, 1896). Meanwhile, in the works of S.I. Korzhinsky, the zonal distribution of cultivated fruit trees was also studied (Korzhinsky, 1898). A new almond (now the most common in Tajikistan) – *Amygdalus bucharica* Korsh - was discovered and described by S.I. Korzhinsky as well.

These findings, as well as the wide distribution of mulberry in the gardens of the Tajik Pamirs, witnesses to the ancient introduction work (Felaliev et al., 2011). Elsewhere, the vegetation of mountainous Bukhara and the fruit trees of Darvaz Ridge were described in the works of V.I. Lipsky (Lipsky, 1905). Furthermore, information about wild and cultivated fruit crops (the most widespread in the regions of the Pamir-Alay mountain system) was outlined in the works of A.A. Dylevsky, and their exceptional diversity was noted. During this period (the pre-revolutionary stage), the foundations were laid for the subsequent study of wild and cultivated fruit crops (Dylevsky, 1905). The period from time immemorial to 1917 can be considered the first period in the history of the development of fruit growing in Tajikistan. The collections and vegetation descriptions of I.A. Raikova in 1923 and 1927, the botanical collections of L.V. Lanina in 1928, and the first reconnaissance of botanists from the Central Asian State University (SAGU) were the most prominent botanical works conducted in the mountainous regions of Tajikistan in the first 15 years after the revolution. The next stage in the development of the study of wild fruit trees is associated with the founding of the Tajik Academy of Sciences and the organization of complex expeditions led by N.I. Vavilov.

According to the analyzed materials obtained during these expeditions, M.G. Popov identified several centers of formation of primary foci of the primary cultures of fruit trees, including the Tajik varieties. As a result of active shaping and selection, well-known Tajik varieties of apple and pear trees were thus officially recorded (Popov, 1935).

Of particular importance with respect to knowledge of fruit trees in Tajikistan are the works of P.N. Ovchinnikov dedicated to Central Asia in general and, more specifically, the Pamir-Alay landscape's ecology, formation, history, and classification (Ovchinnikov, 1974). In the third period of the study of fruit crops and their introduction between 1940 and 1990, along with A.V. Gursky, Yu.L. Sokolov, L.F. Ostapovich, N. Mirzobaytov, M. Shakarmamadov, and others, the head of a laboratory of high-mountain fruit-growing made a significant contribution (specifically from 1977 to 1985), namely Yu.S. Korzinnikov. He had notable input in the introduction and study of the morphobiological characteristics of apricot and walnut under botanical garden conditions, in addition to subtropical crops and seabuckthorn. A systematic variety study of fruit crops, in particular apricot, was started by Yu.S. Korzinnikov (Korzinnikov, 1995). It should also be noted that significant works were undertaken by researchers of the laboratory of high-mountain fruit growing in Gorno-Badakhshan (GBAO), carried out from 1991 to 1995 under the supervision of A.M. Mamadrizokhonov and between 1995 and 2005 under A.S. Felaliev (Felaliev, 2003). In these works, natural groves of relict pear trees in Tajikistan (Kion pear and Yamchun pear) were considered. For some fruit varieties, only a single representative was found, and all such findings are of interest not only with regard to the species composition of the GBAO flora, but also for Tajikistan as a whole. In particular, they can be useful in breeding work. In the works of M. Mamadaliyeva, issues of the research conducted to identify local varieties of fruit crops in the Kulob zone, Gissar, and Rasht valleys of Tajikistan were considered and discussed. In total, more than 50 were found and saved from extinction.

Meanwhile, fruit crop nurseries were established in an area of 1.0 ha for the grafting and propagation of local rare varieties (Mamadaliyeva et al., 2013). M.S. Akobirov, in his work, considered issues related to the conservation of local varieties of apple and pear in Tajikistan, and collected 64 local forms of apple and 34 local forms of pear in Tajikistan. Moreover, the value of these forms for breeding was also indicated (Akobirov, 2019). In the works of A.R. Nazarov and his colleagues, materials acquired through many years of research on the biological characteristics (e.g., rhythm and duration of growth, rhythms of flowering, fruiting, intrabud development of vegetative and generative organs, as well as periods of rest and stability) of 10 wild fruit species introduced under the conditions of the Central Botanical Garden of Tajikistan were outlined. It was shown that a crucial aspect behind the successful introduction of these species was the compatibility of genetically-determined seasonal development rhythms with the natural rhythm of the new conditions in which they were being cultivated (Nazarov et al., 2012). Furthermore, cultivated fruit crops in the Sughd region of Tajikistan were studied in detail and listed by A.A. Gafarovov and other researchers (Gafarovov et al., 2018).

In different periods, multidirectional studies were carried out on the almond genus, including *Amygdalus bucharica Korsh*. Thus, the researchers of a branch of the VIR Crimean Experimental Breeding Station under the supervision of I.S. Chepinogi studied and preserved 114 almond genotypes of four species (in this work, the almond is referred to as the genus *Prunus*: *Prunus amygdalus* (L.) Batsch., *P. fenzliana* Fritsch., *P. bucharica* (Korsh.) Hand.-Mazz., and *P. nana* (L.) Bent et Hedr). Based on a long-term study of the main indicators of adaptability to the stresses of the winter-spring period, the biological characteristics of the passage of phenological phases were established, such as the timing of the end of organic dormancy and flowering. In particular, the sources of resistance of flower buds to various factors in the winter period and the late timing of the onset of flowering were identified. An evaluation of heat resistance, as well as drought resistance, of forms based on the study of the parameters of the water regime of leaves was delivered by Chepinoga et al. (2016).

Moreover, in the work of V.I. Avdeev, electrophoretic polypeptide spectra of wild-growing species of almonds from subgenera and sections of true almonds *Amygdalus* were studied (Avdeev, 2016). It was revealed that the species clearly differed only in the zone of the main legumin-like globulins. In terms of number of common components, vulgaris, Bukhara, and Vavilov almonds are the closest (37-48 components, or 60-77%). This is explained by their related origins and introgressive hybridization when the ranges were combined in the past. Kazimriez Browicz & Daniel Zohary in their article reviewed the taxonomic relationships, morphological distinction, geographical distribution, and ecological specificities of 26 species of *Amygdalus* L. (Kazimriez & Zohary, 1996). It also surveyed the intra-genetic structure in this genus, stressing the fact that these fell into five groups of closely-related vicarious species. Within each group, species are separated from one another geographically (in some cases by altitude). Inter-specific sterility barriers were found to be absent, or only weakly developed, in *Amygdalus*, and numerous inter-specific hybrids (particularly between the crop and various wild almond species) were detected. Therefore, most (possibly all) wild almond species constitute the primary gene pool of the cultivated nut crop (Kazimriez & Zohary, 1996).

The fig (*Ficus carica* L.), one of the first cultivated trees in the world, is grown in many parts of the world with a moderate climate (Barolo et al., 2014). Fig trees probably originated in the Middle East and were then naturalized in many places, becoming an important crop worldwide today. Wild forms of it are found in various regions, including Mediterranean, Arabia, and Asia Minor, as well as in Central Asia and Transcaucasia (Condit, 1947). It is considered morphologically gynodioecious but functionally dioecious and has its own specific pollinating wasp (Kjellberg & Valdeyron, 1984). Almost all grown cultivars are the result of old selection and maintained by vegetative propagation (Storey, 1975). Moreover, hundreds of cultivars are listed in the literature. Self-devised descriptors, including various pomological, agronomic, and technological characteristics as well as molecular markers, are successfully used for variety differentiation and germplasm description (Mars, 2003). Morphometric and molecular analysis has revealed high genetic diversity within cultivated fig germplasms (Elisiario et al., 1998). Further study is, however, needed to better understand the variability structure. Fig cultivation still attracts interest, and there is a need to develop varieties producing high-quality fruits (Kjellberg & Valdeyron, 1984). The threat of genetic erosion has become evident, particularly for cultivars of the Smyrna type (Storey, 1975). Numerous collections have been established in different countries, while new approaches are being developed for fig breeding. In addition, alternative methods for genetic resources management must be considered. The establishment of reference collections, the adoption of a universal descriptor list, and guidelines for the safe movement germplasms, and the definition of variety standards would all be very useful (Mars, 2001). In Tajikistan, nine forms of fig have been noted (Popov, 1929), and wild figs, in comparison with Kopet-Dag figs, are distinguished by their smaller variety of fruits and leaves (Zapryagaeva, 1964). In Tajikistan, high-yielding and frost-resistant varieties are mostly used, such as Vakhsh, Grin-iskiya, Kadota, Dalmaty, Asali, Anjirizard, and Siyokh (Zagreblenny, 1989).

Malus sieversii (Ledeb.) M. Roem., a wild apple species native to Central Asia, is recognized as a major progenitor of the domesticated apple, *M.×domestica* Borkh (Way et al., 1992). In ancient times, apple seeds and trees were probably dispersed from Central Asia eastwards to China and westwards to Europe via trade caravan routes popularly referred to as the Silk Road (Juniper et al., 1999). In the 1920s, Vavilov traveled through Central Asia, reporting that large wild stands of M. sieversii existed in specific localities, and suggested that the region was a center of origin for the domesticated apple (Vavilov, 1987). Djangaliev (1977), while confirming the contemporary existence of wild apple forests, also noted that they were under pressure in some areas because of urbanization, agriculture, grazing, and wood harvesting. In the 1980s, the United States Department of Agriculture (USDA) National Plant Germplasm System recognized that *M. sieversii* was a critical species that lacked representation in its Malus collection at the Plant Genetic Resources Unit (PGRU) in Geneva, N.Y. (Luby et al., 2001). The material was of critical importance because existing cultivars of the commercial apple have a narrow genetic base, with most commercial production being based on very few cultivars (Kresovich et al., 1988; Morgan and Richards, 1993; Noiton and Alspach, 1996). *Malus sieversii* could be a valuable genetic resource to increase the genetic diversity of the domesticated apple for important horticultural traits (Janick et al., 1996; Korban, 1986; Way et al., 1992). *Malus sieversii* has been studied for a long time and is actively used by the local population in Tajikistan. As a result of long-term expeditionary research of the Western Pamirs to study the gene pool, morpho-biological features, and polymorphism of the apple tree, R.S. Felilaev and colleagues identified and described 245 forms of apple tree in this high-mountain area (Felilaev et al., 2015). Studies have also shown that the most productive forms exceeding the standard are Surkhseb, Kavchay, Takhpakmavn, Dursher, Kaparseb, Sebrakht Rushan, Zhovud, Takharvinch, and Dasht. Medium-yielding forms include apple-tree forms, the yield of which is at the level of the standard or exceeds it by no more than 15% (these include Karanak, Sabzak, Samarkandi, Safedmun, Saidshoi, and Kilomun). Apple trees with yields of 26-35% below the standard are classified as “low yielding forms.” The selection and economically valued forms of local varieties of the Sievers apple tree in Tajikistan were also studied by H.N. Nazirov (2011).

Pyrus tadshikistanica **Zapr** is an economically important but taxonomically difficult member of the subtribe Pyrinae (formerly subfamily of Maloideae) of Rosaceae (Campbell et al. 2007). According to paleontological evidence, the origin of Pyrus dates back to tertiary or possibly even more ancient times (Rubtsov, 1944). It appears to have originated in mountainous regions of western and southwestern China (Rubtsov, 1944). Pyrus comprises 41 species (Browicz, 1993, Zamani et al., 2009b, Zamani and Attar, 2010) in the temperate zones of the northern hemisphere (except North America). Moreover, it exceptionally entered northwestern Africa (Browicz 1993). The area where Pyrus grows can be divided into the following two main regions: the first includes Iran and extends to central, southern, and western Europe, northwest Africa, and southwest Asia from Anatolia to Turkmenia; and the second region extends from southwestern Afghanistan through northern Pakistan and the Himalayas to China and Japan (Zamani et al., 2012).

The data presented in the literature contain limited information about the study of *Pyrus korshinskyi* Litv and mainly relate to conservation and some general issues of the study of the genus *Pyrus.* V.I. Zapryagaeva indicated the growth of five species of pear in Tajikistan, of which *P.communis* L. was found only in cultivation (Zapryagaeva, 1964). Moreover, wild pear species included *P.bucharica* Litv., *P.regeli* Rehd., *P. tadshikistanika* Zapr. and *P. cajon* Zapr. The last two were described by V.I. Zapryagaeva (1964). Even A.V. Gursky [5] noted that in the lower parts of GBAO (Darvaz and Vanch), Korzhinsky pear trees of can be found in small numbers *(P.korshinskyi* Litv.). Various forms of tall pears are of great practical importance. Indeed, among the tall forms of pear, there are very productive trees with large fruits (Elchibekova et al., 2010). According to A. Orozumbekov et al. (2014), four species have shown evidence of a bimodal distribution of stem diameters, which could be attributed to fuelwood harvesting, as indicated by a socio-economic survey. These results suggest that unsustainable land use practices may be impacting negatively on populations of threatened fruit tree species, and also highlight the need to regulate local forest use to ensure that threatened fruit and nut tree species are effectively conserved, as well as the need for targeted actions to be taken to conserve the most threatened species, such as *P. Korshinskyi*.

Today, *Punica granatum,* as a fruit, not only attracts substantial public interest but also considerable research focused on its medicinal properties and role in the food industry (Akbarpour, 2009). Natural populations of these species have an invaluable gene pool; their fruits are used for food by the local population in fresh and dry form, because they contain a significant amount of carbohydrates and are rich in vitamins. At the same time, to create varieties of pomegranate and persimmon that are resistant to various pathogens and environmental factors, individuals isolated in natural habitats can be donors of valuable traits. For example, the Caucasian persimmon is successfully used as a rootstock for Eastern persimmon (Sharipov, 2007). It is already demonstrated in various literary sources that introductory studies on the above-listed plants have been carried out insufficiently both in Tajikistan and in many other subtropical zones (Boboev, 2010). Therefore, the study and accumulation of scientific results on the biology, ecology, and physiology of subtropical plants on the vulgaris pomegranate (*P.granatum* L.) and Caucasian persimmon (*D. lotus* L.), which grow in different environmental conditions of Tajikistan, contribute to the development of the biological foundations of these species, as well as substantiation of recommendations for the conservation of their natural gene pool. In the works of I.A. Boboev, the morphological and physiological-biochemical features of wild-growing populations of P. granatum L. were shown, differences in the timing of the development phases were established, and the phenospectra of the studied plants depending on the place of growth were also compiled. In these species, a protective reaction against dehydration in dry subtropics revealed itself in terms of water-retaining capacity, transpiration rate, and water deficit of leaves (Boboev, 2014). In the works of G.M. Levin, the results of a comprehensive study of the Punica granatum (pomegranate) in Turkmenistan, other regions of Central Asia, and the Caucasus are summarized, while data on morphology, ecology, geography, and biological features are given. Moreover, it is indicated that the pomegranate is one of the oldest cultivated species from a list of the most important subtropical fruit crops, with its prospects for use in medicine also highlighted. It currently has a decreasing natural range and is a protected species in a number of countries (Levin, 2007).

3. Materials and Methods

3.1. Objects and Materials of the Research

The objects under study are unique local wild species and local varieties, namely *Amygdalus bucharica* Korsh., *Ficus carica* L., *Malus sieversii* (Ledeb.) M. Roem., *Pyrus tadshikistanica* Zapr., *Pyrus korshinskyi* Litv., and *Punica granatum* L. Meanwhile, the materials under study are cuttings, seeds, and root suckers of these species and varieties.

3.2. Research Methods

3.2.1. Location Identification Methods

3.2.1.1. Review of Literature on Herbarium Collections

In the course of the work, our own herbarium collections and samples stored in the herbarium funds of Tajikistan (namely Dushanbe (TAD) and Khorog (TAD), and Russia (Moscow (MHA, MW), St. Petersburg (LE), and Novosibirsk (NS, NSK)) were used. To identify the general distribution and specific distributions in certain regions of Tajikistan, literary sources on the flora of the former Soviet Union and flora of Tajikistan were studied.

3.2.1.2. Using public Data Platforms GBIF (https://www.gbif.org/), iDigBio (https://www.idigbio.org), and NPSRC (http://www.cvh.ac.cn).

In today's information age, massive species distribution data can be obtained through public platforms, such as GBIF (https://www.gbif.org/), iDigBio (https://www.idigbio.org), and NPSRC (http://www.cvh.ac.cn). Based on these data on species distribution and environmental factors (e.g., temperature, precipitation, topography, soil, and solar radiation), we can obtain ecological data for taxa analysis. On the one hand, we can trace the evolution of ranges and ancestral niches based on species distribution models (Khabbazian et al., 2016; Guillory, Brown, 2021). On the other hand, based on the available ecological data, it is possible to estimate the degree of differentiation among taxon niches in these two territories (Yin et al., 2021). Meanwhile, quantitative methods were used to test for obvious niche shifts during migration of taxa within large regions.

3.2.1.3. Identification of New Locations and Field Research

Field studies were carried out using the classical route method whereby the study area is covered by a uniform network of routes. While following these routes, floristic descriptions were compiled. Routes were made in such a way as to cover the greatest possible variety of habitats, and, within each of them there was a segment of the route of maximum length. The greatest diversity of habitats was observed in the valleys of large rivers, in the basins of ancient lakes in areas with a dense network of ravines, and near the edges of river valleys. When moving along the river, it was important to cross the river valley several times, exploring both banks. Similarly, when working on ravines, it was important to examine both of their slopes, as well as to go along the valley bottom and into the branches. While studying a flat area with uniform vegetation, the route is planned in zigzags and loops so that, while lengthening the path, some rare plants were not missed. Here, it was more rational to use large-scale maps and forest plantation plans for planning routes. In forest areas, old-growth plantations and types of forest that are not typical of this area were of greater interest. When studying the flora of meadows, more attention should be paid to the slopes of ravines and gullies, but, when focusing on steppes, the focus should be directed toward the slopes of eastern and southern exposures. In addition, if there are bedrock outcrops in the study area, special attention should be paid to them.

On the route, it is useful to determine its length using a GPS navigator or a map. For multiday studies, it is not necessary for one route to start at the end of the previous one.

When moving along the route, the encountered plant species were recorded in the field diary, with unknown ones entered in the herbarium for further identification. Records were kept along the way, or stops were periodically made at which time detailed lists of species were written, after which the researcher moved further. In the latter stage, it was useful to annotate each floristic list with comments on the geographical location and, with GPS navigator, the records kept of the exact geographical coordinates system.

3.2.2. Habitat Mapping

The grid distribution map of all species was created in ArcGis, using the same approach as Baasanmunkh et al (2022).

3.2.3. Study of the State of Fruit Tree Populations

The methodology used to assess the state of populations of native fruit trees was based on works on similar crops and in similar regions (Laz'kov, Kulikov, 2013). Research was conducted with the goal of preserving and restoring unique local wild varieties of plants with the help of communities living in the Kulob zone of Khatlon region in Tajikistan. The allocation of sites for subsequent monitoring was carried out after completion of the literature review, herbarium collections, public information platforms, such as GBIF (https://www.gbif.org/), iDigBio (https://www.idigbio.org) and NPSRC (http://www.cvh.ac.cn), and field research. All selected areas had to be marked with their common names, as well as assigned coordinates and altitudes. This information had to be digitally saved.

Regular monitoring studies must be done at least once a year during the flowering period for every species. In addition, it is advised to map the traffic route prior to a trip in order to ensure maximum coverage with minimum obstacles along the way. During a monitoring study, the group moves from one area with a rare type of vegetation to another using GPS and geographic elements for guidance. If a single tree is found at the survey point, then the area of the monitoring description should be circular with a radius of five meters around the tree. If a group of trees is found, the area should be a 20 ***x*** 20 m square, the corners of which must be marked by pegs so that the area can be easily located again in the future. If the vegetation surface extends beyond these parameters, then the monitoring area is to be expanded to the needed size, and the GPS coordinates are to be marked at the central point of the area. Furthermore, the altitude, the slope exposure (northern, southern, western, or eastern), steepness (0°-15°, 15°-30°, or 30°-45°), the area's size in meters, the shape of the slope (convex, concave, straight, convexo-concave, or concave-convex), and the location of the slope (top, middle, or bottom part) must be noted.

Even if old data from previous studies are available and the landscape has not undergone major changes (due to a mudslide, avalanche, etc.), the information should still be updated. Moreover, the areas must be photographed and numbered or marked with the time and date at which the pictures were taken so that the files can later be easily identified and sorted (the date/time setting on the camera should be checked and corrected, if needed). In addition, new photos must be taken regardless of whether the given areas have been photographed before. If a single tree is being studied, it must be photographed from an angle that reveals all of its remarkable details. Meanwhile, a group of trees must be photographed from every angle of the area moving inwards. If the number of rare or endangered species of woody plants grows, new trees must be noted too.

In addition, the number of trees of such species must be documented; at the same time, if a single root has multiple stems, every single one of them must be marked as a separate tree. Additionally, the median height of the crown and the median thickness of the stems (the diameter, not circumference), which could be measured either by eye or using a measuring tape, must be noted. Elsewhere, stand density is an important indicator of a population's health. There are three types of stand density: closed – many trees with touching crowns; medium – some trees with touching crowns; and sparse – no trees with touching crowns. Another health indicator of a population is the presence of undergrowth, which is why it is important to document the quantity of seedlings and young trees. For simplicity, these are to be regarded as the same thing. Their quantity in the area should be documented as well (0-10, 10-50 or 50-150). Meanwhile, the anthropogenic impact on a population can be measured by the number of cut-down trees or stumps. It should also be noted whether there are any cut-down trees of rare varieties and, if so, the number thereof. Another important indicator is the age composition of a population. Accordingly, the ages of trees in a population should be documented, as well as whether old trees or young trees are, for some reason, absent in the given population. Stability and the current state of a population are determined by the proportion of the various age groups it contains. A population is considered stable if it consists of plants of every age (young and old). The absence of old trees indicates that the population is at the stage of renewal, while the absence of young trees and seedlings indicates an unstable population that has no future. The health of trees is important as well, which is why any damage, such as dead branches, must be noted. The quantity of dead branches can be estimated by the eye. With regard to the health of woody plants, it is important to check if it is affected by the grazing of animals. If nearby pastures are overwhelmed, livestock may be inclined to move into the forest and inevitably damage woody plants. Such damage is classified as follows: none, minor (if some branches are damaged), and severe (if many branches are damaged).

Furthermore, the overall health of the forest ecosystem in the studied area must be evaluated. Firstly, the vegetation should be divided into levels: grass, bushes, and trees (young and mature). Secondly, the height of each level should be measured either by the eye or measuring tape. Thirdly, the percentage of the projected foliage cover of each level should be noted separately. This can be determined by eye; however, it is best to use a scheme to determine a foliage projective cover so that different researchers can still yield similar results. The overall sum of a projected foliage cover can exceed 100%, as different levels interlap, and the same area can be covered by several levels. Each level should be briefly described, for example, whether there is any damage present because of cutting or animal grazing. The data gathered in the field work must be entered into an Excel form, including data from old monitoring sites as well as new ones. At the same time, the new monitoring sites should be given new unique names and continue to be studied regularly in the future. Based on the results of the field research, each population must be evaluated (using a points system).

To summarize the above, when describing the current state of a population, the following characteristics should be noted:

1. Stand density: "closed" – many trees with touching crowns (3 points); "medium" – some trees with touching crowns (2 points); and "sparse" – no trees with touching crowns (1 point);
2. Presence of young non-bearing trees: "dense" – many (50-150) young plants (3 points); "medium" – small number (10-50) of young plants (2 points); and "none" – few to no plants (0-10) (1 point).
3. Presence of cut-down trees or stumps: "none" – zero cut-down trees or stumps (3 points); "minor" – 1-3 trees or some branches have been cut down (2 points); and "severe" – more than three trees have been cut down (1 point).
4. Age composition of plants: plants of every age (young and old) are present (3 points); no old trees, but only seedlings and young trees (2 points); and no young trees, and only old ones are present (1 point).
5. Presence of dead-wood: "none" – zero dead branches (3 points); "minor" – there are a few dead branches (2 points); and "severe" – there are dead trees (1 point).
6. Damage caused by livestock: "none" – no branches are damaged (3 points); "minor" – there are a few damaged branches (2 points); and "severe" – many branches are damaged (1 point).

The current state of a population is evaluated as follows: based on the results of the studies, all points are added together, with a higher sum meaning a population is in a better state. Every year during the monitoring period, a population in the area is evaluated using a points system, making it easy to trace the changes in its overall health over time.

3.2.4. Organization of Fruit Tree Nurseries

Materials gathered from working in a similar environment and with related fruit tree species serve as the basis of the methodology and the main direction of nursery development (Turgunbaev et al., 2012).

A fruit tree nursery is created with the aim of getting 1-2 summer seedlings for every fruit-growing zone. When creating a nursery, it is important to note the local environmental conditions. Low temperatures stunt seed germination and the maturing of seedlings after budding. Pertinently, the full growth circle of a fruit trees is approximately 3-4 years, so a nursery provides the optimal conditions for young plants. The survival rate of seedlings from nurseries created in the garden is high. Meanwhile, the modern technique of growing fruit trees is done in three phases and requires two re-plantings. In the first phase, fruit seedlings are planted and used later as rootstocks. In the second phase, the plants are grafted, while the third phase entails growing and harvesting fruit trees in the garden.

The area designated for a fruit tree nursery should be arable, protected from strong and cold winds, and preferably not damaged by late spring frost or hail storms. The best areas to use for fruit tree nurseries are flat land plots or slopes that are not too steep (3-4°), facing south, southeast, or south-west and with rich clay or sandy-loam aggregated soil, free of wireworms, chafers, fen-crickets, or harmful weeds. The rootstock refers to the lower part of grafted plants, which connects scion with the soil. How well a rootstock adapts to local soil conditions and how well it matches the scion's biology (in terms of compatibility, growth rate, etc.) determines the success of the grafted tree. Rootstocks play an important role in the capacity of trees to withstand drought, low and high temperatures, and soil salinity, among other challenges. Moreover, rootstocks used in fruit-growing practice can be characterized based on their origin as wild or cultivated varieties; based on the growth type as high-growing, medium-growing or low-growing; or based on their propagation as a seed or vegetative type. Seed varieties of rootstocks are distinguished by their large growth and longevity as well as their adaptability to different types of soil, which improves the grafted trees' resistance to hostile conditions and lack of water. At the same time, such trees take a long time to reach fruit-bearing age. Polymorphism is responsible for significant variations in growth rates, patterns of development, longevity, and productivity, which often occur with seed propagation, thus making vegetative propagation a more popular choice. There are many advantages of using vegetatively-propagated rootstocks (including small crowns and fast growth); however, there are also some disadvantages, such as low propagation rate and high transmission rate of viral diseases to offspring.

A fruit tree nursery consists of the following parts: (1) a zone of rootstock seed germination, where seeds for growing rootstock seedlings are prepared, where there is a stool bed of vegetatively-propagated rootstocks, which produces rachises and stems of cloned rootstocks and a garden of propagated mother trees and their varieties, which provide scions for grafting and layering of berry varieties; (2) a zone of rootstock propagation consisting of a planting area and cuttings' harvesting area; and (3) a zone where grafted plants that are ready to be planted (saplings) are grown. A sapling zone consists of three parts referred to as nursery fields (I, II, and III), which differ from one to the next according to the age of the plants they grow and the methods used to care for them.

The area of component parts of a nursery should be proportionate to the volume of planting material they produce. The size of a field that is planted every year, thus referred to as "recurrent," serves as the basis for calculation here. One hectare of a recurrent nursery field requires 0.225-0.33

hectares of rootstock propagation zone or 0.3-0.4 hectares of vegetatively-propagated rootstock stool bed, 1 hectare of rootstock-seedling garden of pome and stone fruit varieties, and 3 hectares of a propagated mother tree garden. It is important to remember that a 4-5-field crop rotations is used to grow rootstocks and a 8-field crop rotation is used to grow saplings. In addition, 30-35% of the entire area of a nursery is used for roads and hedgerows.

Clonal rootstocks are grown in stool beds using agricultural techniques appropriate for each variety's biological requirements. Thereafter, rootstocks are moved to a stool bed in the second or third year after the initial planting. Propagation is normally done by vertical (rarely horizontal) layering. For that, mother plants are grown in specially-designated areas. When propagating by horizontal layering, stems remain attached to the mother trees. In fall, the soil is plowed around mother trees and then dug over around the branches. In spring, the soil is harrowed; shallow grooves are made along the rows, in which the strongest branches are placed. Other branches are cut into 2-3 buds for additional propagation. Strong branches are then attached to the ground by wooden hooks and covered by soil. Meanwhile, new shoots sprung from buds are spudded several times during their vegetative period. By fall, the layers develop their own roots, after which they are separated from the mother plants and cut into the number of shoots they have produced. Vertical layering propagation starts in early spring, when all branches of a mother shrub are cut at 2 cm above the ground. The buds on the created stumps then produce shoots. When they reach a height of 12-15 cm, they are covered by 10-12 cm of soil. As they grow, the process is repeated 1-2 more times until they form a mound of 25-30 cm, leaving the top parts exposed. In fall, the soil is removed; all shoots that have produced new roots are detached from the mother plant and cut at a height of 35-45 cm.

Seeds for growing rootstock are prepared in seed beds, commercial gardens, or wild areas, where mother trees are carefully selected and tested. Well-developed fruits are harvested, but seeds from small fruits or underripe fruit are not suitable for propagation. In addition, seeds from winter varieties of pome fruit are collected when they achieve full ripeness in the storing process. Seeds and stones from small batches of fruits can be extracted manually, while large quantities of seeds are easier to collect from canneries and primary winemaking facilities provided that they do not use thermal processing or sulfurization, which kill the embryo of the seeds. Cleaned and crushed fruits are frayed or immediately pressed. Seeds are then extracted from the pomace, dried, sorted, and stored until stratification. The storage space must be dry, dark, well-protected from rodents, and well-ventilated with a temperature of 0-2$°C$ and humidity of 50-60%.

Prior to planting, seeds must be prepared for germination, which requires adequate moisture, a low temperature, and the free flow of air. These conditions are ensured during the stratification process. Seeds are mixed with 2-3 times the amount of sifted sand with the moisture level of 60% (4-5 times the amount for stones) or with peat pellets, poured into boxes in a 30-40 cm thick layer and then stored in a facility with a temperature of 5$°C$. The stratification of apple and pear seeds takes 100-120 days. The beginning of the process is determined by its duration and approximate sowing time in the field, while stratification is considered complete when 10-15% of the seeds sprout. The seeds are then planted into soil that has been prepared by being plowed 30-35 cm deep and well-fertilized 3-4 months prior. Right before sowing, the area is leveled and loosened with cultivators and a two-row harrow. In southern locations, planting can be done in fall, while, in places with harsh winters and volatile snow conditions, unprepared seeds can be planted in spring after stratification. The distances between rows, placement depth, and sowing standards depend on specific characteristics of the seed variety's growth and size, the mechanical properties of the soil, and the mechanization conditions required for plant production. Seedling care includes thinning them twice, removing weeds systematically, loosening the soil, watering the plants 2-7 times, and performing adequate pest and disease control. In fall, when shoots grow, saplings are dug out, sorted, and prepared to be replanted, sold, or stored in winter.

The characteristics of a variety determine its soil treatment system in a nursery. For sowing purposes, the depth of tillage should be at least 25-30 cm, while, for growing seedlings, it should be at least 35-40 cm. Deep tillage improves the water and air regimes of soil and is one of the best methods for controlling weeds, pests, and diseases as well as facilitating strong root system development. Soil tillage incorporates organic and mineral fertilizers: 5-6 centners of superphosphate per one hectare of land, and 25-30 tons of manure per one hectare of land. Ammonium nitrate is used as a fertilizer in the early stages of vegetation. Soil must be kept loose and well-watered.

The following rules must be observed when preparing seeds: (1) fruits must be grown in a controlled environment, such as seedbeds, forests with wild tested trees, or commercial gardens; (2) the chosen fruits must be well-developed, large or medium in size, ripe, located in the upper parts, and on the periphery of the tree crown; (3) seeds must be extracted from the fruits using a cold method; (4) fruit crushing and the pomace removal should be done quickly, with the water frequently being changed (seeds should not be submerged in water for more than 1-2 hours); (5) seeds should be spread in a thin layer in the shade, left to dry for 2-3 days, and frequently tossed until their moisture level reaches 10-11%; (6) seeds should be cleaned using winnower and sorted by size; (7) prepared seeds must be labeled with the name of their species, variety, or form and date of preparation; and (8) seeds must be stored in cool, dry, and well-ventilated facilities either in sacks or sometimes in bottles. The storage temperature should be 0-50°*C*, while storage duration should not exceed 2-3 years. Meanwhile, pre-sowing preparation is done as mentioned above, by stratification. For that, seeds are mixed with washed sand (at a seed:sand ratio of 1:3 or 1:4), after which the mix is watered, spread in a thin layer, and stored at a temperature of 3-50°*C*. Apple and pear seeds with a short rest period could also be planted in open ground in October or November. They generally go through the rest period in natural conditions. Meanwhile, seeds of other species require stratification prior to planting.

For seed sowing and seedling planting in a primary field, tillage and fertilization are most effective crop rotation conditions. The soil must be plowed 40-45 cm deep no later than two months prior to planting; it should also be leveled and compacted. Soil cultivation is conducted as needed, going as deep as 6-8 cm. The optimal sowing time is generally spring or fall, while apple and pear seeds are planted in well-fertilized soil between rows meant for seedlings. In addition, seeds are placed in nests at a distance of 20-25 cm from each other. In fall, in well-watered soil, the ends of seedling roots are cut with a special knife. Only one well-developed seedling is left every 20 cm, as the rest are dug out and sorted and the leaves are removed. Open ground (i.e. field zero) is primarily used for growing apple and pear saplings. Small seedlings with normally developed root systems are suitable for this purpose, and spring is the best time for planting. In the manual planting process, it is advisable to make furrows that are up to 15 cm deep and then plant seedlings using a shovel. During the spring-summer period, plants need to be watered 4-5 times, and soil should be kept free of weeds. Within one year, seedlings will be ready for budding.

Seedling care requires regular watering and loosening of soil. In order to grow rootstocks with a densely-branched root system, the roots must be cut with special knives at a depth of 10-12 cm when the seedlings reach 8-10 cm (in the 3-4 leaf phase). The plants must then be thinned so that there is a 5-6 cm row between seedlings of pome species. Seedlings should be dug out in the middle or at the end of October. Prior to that, the soil must be watered, and leaves must be removed. Seedlings can be dug out using a shovel or a plow. A well-developed seedling of a pome species must have a root collar diameter of 5-6 mm and roots that are at least 15 cm in length.

3.2.5. Training Farmers

The following priority topics were identified regarding training farmers:

1. Organization of seminars aimed at identifying the use of wild species by local communities, the local varieties, and collection of information.
2. Such seminars contribute to the identification of local varieties of wild species that are resistant to infection, pests, and drought, and which also bear fruits of desirable qualities, such as being large in size, having a pleasant taste, being resistant to disease, and possessing the ability to stay fresh for a long time to make transportation easier.
3. Consultations and preparation work for the creation of nurseries that use local varieties of wild species.
4. Identification of the project's goals and objectives for local communities and making arrangements regarding the organization of a nursery aimed at preservation and propagation of valuable genotypes of wild species and varieties all further facilitates the creation of nurseries and motivates local farming communities.
5. Seminars with the participation of horticultural experts, publication of methodological manuals, and practical workshops.
6. This entails educating local farming communities about unique wild fruit genotypes of the local flora, their advantages in breeding, and their adaptability to global climate change, all of which serve as arguments in favor of their wider use and preservation. Seminars provide local communities with invaluable experience and help to identify specific agricultural methods used by local farmers, which tend to be suitable for the areas where nurseries are planned to be constructed. Implementing methods based on scientific agricultural knowledge yields high production volumes and reduces labor and financial costs at all stages of growing fruit-bearing plants.
7. Organization of nurseries according to the local climatic conditions, site preparation, and provision of local communities with necessary materials and equipment.
8. A lack of nurseries in mountain territories fuels the need to acquire planting material from nurseries located in lowland areas. The differences in vegetative periods of plants taken from different climatic conditions affects the adaptability of the planting material and its acclimatization. As a result, the creation of local nurseries is strongly needed. Supplying local farming communities with equipment and materials necessary for agricultural practice helps to motivate them and facilitates the sale of highly-resilient planting materials that suit the local climatic conditions. All such activities have a positive effect on the economic wellbeing of local farmers and contribute to building a wide assortment of sustainable horticultural crops for local communities.
9. Annually monitoring of nurseries, advice on identifying and resolving problems, and optimizing the growth of the planting material.
10. Annual monitoring allows for a comprehensive approach to choosing or eliminating additional fertilizers, correcting methods, and determining periods of agricultural activities.
11. Working with forest services, local authorities, and educational institutions.
12. Working with forest services and local authorities streamlines organizational processes and facilitates support of local farming communities. Moreover, educating students helps them to learn from a young age about nurseries and sparks an interest in the subject, which might, in the future, motivate them to contribute to the development of existing local nurseries and the creation of new ones.

4. Results

4.1. Overview of the taxa

Amygdalus bucharica Korsh., *Ficus carica* L., *Malus sieversii* (Ledeb.) M. Roem., *Pyrus tadshikistanica* Zapr., *Pyrus korshinskyi* Litv., and *Punica granatum* L.

4.1.1. Taxonomy and Conservation Status

Amygdalus bucharica Korsh.

Amygdalus bucharica is one of 50 species of wild almond in the *Amygdalus* genus of the *Rosaceae* family. Of these, 14 species grow throughout the former Soviet Union territory, and five are found exclusively in Central Asia (Zapryagaeva, 1975). All species from the genus *Amygdalus* are present in Asia, particularly in its southwestern and central parts. Only two species, namely *A. nana* and *A.webbii,* are also represented in Europe, which accommodate the majority of these species. The greatest concentration of species, as well as the largest number of hybrids, is found in Iran (almost 20 taxa), Afghanistan, and eastern Anatolia. A number of species are also distributed across the Middle-Asiatic republics of the former Soviet Union, particularly in Turkmenistan and Kyrgyzstan, and also in Iraq. It is clear, therefore, that we are dealing here with an Irano-Turanian genus. While some species, such as *A.webbii* and *A.graeca,* also appear in the Mediterranean region, their close connection with the Irano-Turanian species is unquestionable (Browicz & Zohary, 1996). *Amygdalus bucharica* is evolutionally a younger species and so it occupies rather large areas in mountainous parts of Central Asia (about 1 million hectares). Numerous *Amygdalus bucharica* x *Amygdalus communis* hybrids grow under natural conditions (Denisov, 1988).

Amygdalus bucharica Korsh. is not listed in the Red Data Book of Tajikistan. Indeed, *Amygdalus bucharica* was most recently assessed for the International Union for Conservation of Natura (IUCN) Red List of Threatened Species in 2007, where it was listed as "Vulnerable."

***Ficus carica* L.**

The *Ficus* genus from the Moraceae Lindl. family is made up of about 1,000 species of pantropical and subtropical origins (Wagner et al. 1999). Plants in this genus are all woody, ranging from trees and shrubs to climbers (Neal, 1965). Of these, one species grows throughout the territory of the former Soviet Union, and one is found exclusively in Central Asia (Zapryagaeva, 1964): *Ficus colchica and F. hyrcanica Gross.* They were described from Talysh and Colchis, according to N.K. Arendt (1959), and are varieties of *Ficus carica* and *F. afghanistanica* Warburg. According to M.G. Popov, *F. afghanistanica* is found in the wild populations of Shirabad and Baljuan. According to the observations of V.I. Zapryagaeva (1964), these two species are found only in cultivated plantations. The Latin name *F. carica* refers to the location Caria in Asia Minor, which is supposedly the home of the fig (Neal 1965; Dehgan 1998).

Ficus carica was most recently assessed for the IUCN Red List of Threatened Species in 2007, where it was listed under "Least Concern." Meanwhile, it was listed in the Red Data Book of Tajikistan as an endangered species (2017).

Malus sieversii (Ledeb.) M. Roem.

The Central Asian apple *Malus sieversii* belongs to the *Rosaceae* family (making it related to other fruit trees, including apricots, plums, cherries, and almonds). It is one of an estimated 42-55 apple species in the Malus genus (all of which are native to the temperate zone in the Northern

Hemisphere). About 12 species of *Malus* grow in the Central Asia region, including nine wild and three cultivated. *Malus sieversii* was described by S.V. Yuzepchukov in the Tarbagatai Mountains (along the border of China and Kazakhstan) and is thought to be an independent species (Tatartsev, 1960). Despite the distance between the Tarbagatai Mountains and the Pamir-Alay in Tajikistan, there are no fundamental differences in the *M. sieversii* trees in either geography. However, on the whole, this species is extremely polymorphic and requires further study. Indeed, according to A.S. Felaliev (2003), in the Western Pamirs, only one Malus species grows both in the wild form and in cultivation, and there are 255 different local forms. Many are similar to a number of well-known ancient varieties, such as Charsak seb, Safed seb, Kandak seb, Surkh seb, Khor seb, and Amiri, but they all have a very close morphology to the *M. sieversii* variety (Aleksanyan, 2011). It is believed that *M. sieversii* is a wild ancestor of the domesticated apple, *M. domestica*. The movement along the Old Silk Road allowed the previously isolated M. sieversii to hybridize with other species of apple, namely *M. sylvestris* and *M. prunifolia*. This was facilitated by grafting and eventually led to the domestication of apple trees around 3,000-4,000 years ago (National Geographic, 2018).

Malus sieversii is classified by the ICUN as "Vulnerable," but it is not included on the Tajikistan Red Data Book.

***Pyrus tadshikistanica* Zapr.**
Pyrus tadshikistanica is one of 60 species of wild pear in the *Pyrus* genus. Of these, 40 species grow throughout the territory of the former Soviet Union, and 10 are found exclusively in Central Asia (Zhukovsky, 1971; Felaliev, 2003). According to the morphological and biological features identified by Silva et al. (2014), there are three large biogeographical groups of pears: East Asian, Central Asian, and Mediterranean. Among wild pears, there are forms with a falling cup (similar to plants found in East Asia) (Gursky, 1951) and those with a retaining cup, which belong to the Central Asian group of pears (Feliav, 2003). This species was first described as a wild type of *P. communis* and was later considered a hybrid between *P. communis* and *P. sinensiz*. However, further studies indicate that *P. tadshikistanica* is fundamentally different from *P. communis* and should be considered a separate species. It is often confused with *P. communis,* with which it can hybridize. Schonbeck-Temesy (1969) considers this species feral, but, as it grows in forests remote from human settlements (Zapryagaeva, 1964), it is difficult to agree with this claim. Confirming that species identification is even more complicated when other pears are grafted directly onto wild trees, in this case, the only criterion for establishing the species is the presence of shoots growing from the root of the tree.

Pyrus tadshikistanica is endemic to Tajikistan (Felaliev, 2003) although it is not included in the Red Data Book of Tajikistan. Meanwhile, the IUCN lists the conservation status of *P. tadshikistanica* as "Critically Endangered."

***Pyrus korshinskyi* Litv.**
Pyrus bucharica / korshinskyi is one of 60 species of wild pear in the *Pyrus* genus. Of these, 40 species grow in the countries of the former Soviet Union, and 10 are found exclusively in Central Asia (Zhukovsky, 1971; Felaliev, 2003). According to the morphological and biological features identified by Silva et al. (2014), there are three large biogeographical groups of pears: East Asian, Central Asian, and Mediterranean. Among wild pears there are forms with a falling cup (close to plants in East Asia) (Gursky, 1951) and those with a retaining cup, which belong to the Central Asian group of pears (Feliav, 2003). While *Pyrus korshinskyi* is the accepted name for the species on the catalogue of the Plant List of the Republic of Tajikistan, within Tajikistan, there is some

debate as to whether *Pyrus korshinskyi* and *Pyrus bucharica* are separate species. For the rest of the document, we only use *P. korshinskyi*, although we accept that this issue is not yet resolved.

The ICUN describes the conservation status of *Pyrus korshinskyi* as "Critically Endangered." However, it is not listed in the Red Data Book of Tajikistan (Boboev, 2017).

***Punica granatum* L.**
The *Punica* genus is from the family *Lythraceae J.St.-Hil.* (APG 4, 2016), and there are two species – *Punica protopunica* Balf. and *Punica granatum* L. *Punica protopunica* is endemic to Socotra Island in the Arabian Sea, while *Punica granatum* is widespread across the ancient Mediterranean countries (Zapryagaeva, 1964). Pomegranate (*Punica granatum* L.) was one of the first domesticated fruits to be cultivated (Shaygannia et al., 2016). It is indigenous to Iran and neighboring countries, while it gradually developed into the Central Asia region and the Himalayas, the Eyalet of Anatolia, the Middle East, and the Mediterranean. It also thrives in Arizona and California, and has been cultivated in the Mediterranean region, South Asia, and Middle Eastern countries. Meanwhile, Kandahar in Afghanistan is famous for its high-quality pomegranates. Today, the pomegranate is cultivated in numerous countries across the world including Iran, Spain, Italy, Afghanistan, the United States, India, China, Russia, Uzbekistan, Morocco, and Greece (Babaki, 1997). Iran is one of the biggest producers of pomegranate in the world, where Markazi, Yazd, Fars, Khorasan, and Kerman provinces have the highest production rates (Al-Said et al., 2009).

Punica granatum was most recently assessed for the IUCN Red List of Threatened Species in 2007 where it was listed under "Least Concern." Meanwhile, it is listed in the Red Data Book of Tajikistan as an endangered species (2017).

4.1.2. Morphological Characters

***Amygdalus bucharica* Korsh.**
This is a tree which reaches five meters in height, while, in rare cases, it presents itself as a shrub. There are no thorns on its branches, while the shoots are either glabrous or velvety pubescent. Its leaves are oblong ovate, wide lanceolate or oval, 2.5-5.5(6) cm in length, 1.5-3.5 cm in width, glabrous on both sides or slightly pubescent on the bottom, growing on stalks 0.7-2.5 cm in length. Leaves on one-year shoots are alternated, growing in tufts on short branches. Meanwhile, blossoms are pale pink, growing on short branches or one-year (last-year) shoots; flowers are 1.5-2 mm long, hypanthium is glabrous, cylinder-shaped, or bell-shaped with protruding hairy prongs. Fruits emerge with velvety pubescent pericarp and are irregular-ovoid, compressed, flat-truncated at the base, blunt or pointed at the top, 20-38 mm in length and 15-25 mm in width, while its stones have a smooth shiny surface with either no grooves or slightly indented grooves at the base (Laz'kov, Kulikov, 2013).

***Ficus carica* L.**
These are shrubs or small trees, which are deciduous and can grow to five meters. Their roots are not adventitious, while the bark is greyish and slightly roughened and the branchlets are pubescent. In terms of leaves, the stipules range from 1-1.2 cm and the petioles 8-20 cm. The leaf blade is obovate, nearly orbiculate or ovate, palmately 3-5-lobed, 15-30 x 15-30 cm, cordate base, their margins undulate or irregularly dentate, while the apex is acute to obtuse. In addition, the surfaces are abaxially and adaxially scabrous-pubescent; basal veins 5 pairs; lateral veins irregularly spaced. They are syconia solitary, sessile, green, yellow, or red-purple, pyriform, 5-8 cm, and pubescent; the peduncle is ca. 1 cm, while the subtending bracts ovate, reaching 1-2 mm, while the ostiole has subtending bracts and is umbonate (Flora of North America, 2000).

***Malus sieversii* (Ledeb.) M. Roem.**

Malus sieversii is a tree that reaches heights between 10-12 m and has a trunk typically 20-30 cm in diameter (although very large and old ones can reach heights of 15 m and a diameter of 100 cm). In dry areas, the species is much smaller and bushy in form. The bark of mature trees is dark grey to blackish, with deep longitudinal cracks; in younger trees, it is light grey to greyish-brown and shiny. The shape and size of the crown depends on the living conditions; in trees growing freely, it is wide (10-12 m in diameter), deep, and hemispherical. However, in dense stands, the crown is irregular and often one-sided. Annual shoots are greenish-brown, densely hairy or woolly. The bulbs are woolly, while the leaves of annual and perennial shoots vary in shape and size. They range between 6 and 15 cm in length and, in terms of shape, can be narrowly or widely elliptical, ovoid or almost round, rounded at the apex or pointed at the tip, tapered or rounded at the bottom, tapered at the edge, or serrated or dentated. From above, the leaves are smooth or hairy along the veins; from below, they are densely hairy or woolly (although on rare occasions almost hairless). Petioles (leaf stalks) are 1–4 cm long and are always shorter than the leaf blade. They are hairy, woolly, or almost hairless. The stipules fall off each year but are sometimes persistent until fruit ripening. Stipules are hairy, while, in terms of shape, they are slender and tapering to the end. Inflorescences (flower clusters) have between 3-7 individual flowers (each typically 2-3 cm in diameter) attached to a densely hairy or, more often, woolly, sometimes undeveloped, axis. Each flower contains 5-6 petals which vary greatly in shape (round, ovoid to elliptical, smooth or corrugated) and color (white, pink or, rarely, raspberry). There are typically 19–20 stamens with light-yellow or orange anthers. Meanwhile, the sepals are triangular, sometimes spear-shaped, sometimes narrower, and are bent downward. They are woolly, green or brownish-green, and often have a raspberry-colored strip at the end. The hypanthium (the structure which holds the petals, sepals, and stamens) is scaly and woolly. Fruits weigh up to 100 g and take a variety of different shapes, colors, and sizes. They may be rounded, flattened, or cylindrical; the skin is usually yellow and green in color, although some trees have pink, bright, dark red, or striped fruits. The pulp can be white, yellow, or pink, while fruits can taste sour, sweet, or more often a combination of the two. Fruits have, on average, 15 seeds with an average weight of 0.03-0.04 g. These seeds are brown, sometimes almost red, incorrectly obovate, and have a pointed curved nose (Miravalova et al., 2020).

***Pyrus tadshikistanica* Zapr.**

A *Pyrus tadshikistanica* tree is 15–20 m tall, with a trunk diameter of 35–40 cm, although, in dry areas, it is stunted (2–4 m tall), bushy, with trunks 10–15 cm in diameter. The bark of its old trunks are either grey or dark grey, fissured, and almost smooth. Annual shoots are reddish-brown, smooth, with buds bare or with single hairs. In terms of leaves, the buds are wide and conical, while external scales can be either naked, hairy, or densely hairy. The leaves are 5-6 cm long; they can be oblanceolate (spear-shaped), oval or round, broadly round at the base, short and sharply drawn at the apex. They are usually stiff, leathery, and bare on the top while, on the bottom, they have scattered hairs. The leaves are grooved along the edge, or finely serrated, or can appear smooth (in cases where pubescence (soft downy hairs) hide serrations along the leaf edge). Leaves are attached to petioles, which are typically 6–7 cm long, thin, yellowish, or bright yellow. The leaves of the seedlings are rounded, oblanceolate, and, at the apex, sharply and unequally serrated. Inflorescences (flower clusters) are 3-8 cm in diameter and have 5-6 flowering stems (this means each flower arises from a different point, but reaches the same height, giving the flower cluster a flat-top appearance). Flowers are sparsely haired with petals up to 1.5 cm long, white, paper-like, broad-backed, and sometimes appear round. There are typically 18-22 stamens equal in length, while the ovary is hairy but becomes naked later. Sepals are sharp and narrowly triangular, hairy on the outside, woolly from the inside. Bracts (modified leaves next to the inflorescence) are linear, hairy, and early falling. In addition, fruits are 4-5 cm long, spherical or short pear-shaped and their peel is stiff, with full ripening yellow or dirty green, and a large number of white dots; the flesh is rough, with an abundance of stony cells which are sour-bitter-sweet, while the calyx is preserved by fruits. Seeds are large, black, and shiny, with 3-4 of them in one fruit (Miravalova et al., 2020).

Pyrus korshinskyi **Litv.**

Pyrus korshinskyi is a single or multi-stem tree, often bush-shaped, that typically reaches heights of 6-8 m (although, on occasion, it grows to 12-15 m). The diameter of the trunk ranges from 15-50 cm (up to 120 cm on rare occasions). The bark of its old trunks are grey and deeply fractured (sometimes almost scooped). The crown is hemispherical or ovoid, 8-11 m in diameter. Perennial shoots are greyish-brown and bare, while old ones are reddish or greenish-brown, and shoots of the current year are very pubescent, sometimes woolly. The roots of adult pear trees, being highly branched, help to prevent erosion and destruction; they extend 8-15 m outwards from the base of the trunk and occupy an area 10-12 times the crown projection area. The buds are 5-8 mm long, egg-shaped, greyish-brown, hairy, or almost hairless. With regard to leaves, in shape, dissection, and pubescence, they change with the age of the tree: in seedlings and on shoots, they are sectioned into narrow separate or deeply-incised lobes, each 2-3 mm long and pointed at the edges and sharp at the top. At this stage, the leaves are bare or have hardly noticeable cobweb-like pubescence. Only very rarely will whole leaves develop. Indeed, by the age of 15–20 years, trees have only whole leaves which are typically 5-15 cm long and 1-4 cm wide, are sharp-edged, and are linguae or broadly lanceolate (spear-shaped). In areas treated with irrigation and care, whole leaves appear in seedlings in the fourth or fifth year. Leaves are attached to petioles (stalks) which are 2-7 cm long and hairy, while stipules (small appendages at the base of the leaves) rapidly fall from the leaves. Inflorescences (flower clusters) are 5-15 cm in diameter with each flower attached to a stalk 1.8-2.6 cm long. Flowers are densely hairy and have a diameter of 2.5-4.5 cm, while petals are 1.2-1.5 cm long, and 1 cm wide. Buds are raspberry-colored, and turn white after blooming. Sepals (green structures behind the petals) are 4-5 mm long, narrowly triangular, densely hairy, and have reddish glands along their edges. Typically, there are between 13-28 stamens. The hypanthium (the part of the flower that holds the petals, sepals, and stamens) is goblet-shaped and thick-haired. Fruits are round-shaped (sometimes slightly flattened), 2.5-4.5 cm long, and 2-4.5 cm wide. Their average weight is 15-20 g. They are yellow when fully ripened, sometimes light brown; the skin and the flesh are thick. The taste is sweet, sour, and tart but only becomes edible after being stored for 30–45 days. The stalk is 2.5-4.5 cm long, hairy, and has the same thickness along the entire length, with the top slightly expanding. Seeds are 1-1.2 cm long and 3-4 mm wide, and average weight is 0.15-0.18 g (up to a maximum of 0.32 g). Seeds are usually well-formed and are rusty or dark brown, sometimes almost black and shiny. They also have a sharply-pointed tip (Miravalova et al., 2018).

Punica granatum **L.**

Pomegranate is a shrub that reaches 1.5 to 5 m in height, with more or less irregular and thorny branches and glossy leaves that appear as a deciduous shrub in temperate regions and as evergreen in frigid regions. Looking at its other characteristics, its leaves are seen as reciprocal in newly-grown branches and as integrated in spores. With respect to its flowers, one of them is terminal and the rest marginal, short, or without peduncle, while their color is red and rarely yellow or white, odorless, and two-sex. In terms of its fruit, the Balausta is light red in color to greenish yellow, and rarely, in some species, dark purple. It is 5 to 20 cm in diameter, and its weight varies from less than 200 g to more than 800 g. Seeds are produced in large amounts, are triangular, albumin-free, and embedded in aril (Shaygannia et al., 2016).

4.2. Habitat Mapping in the Kulob Zone of Khatlon region

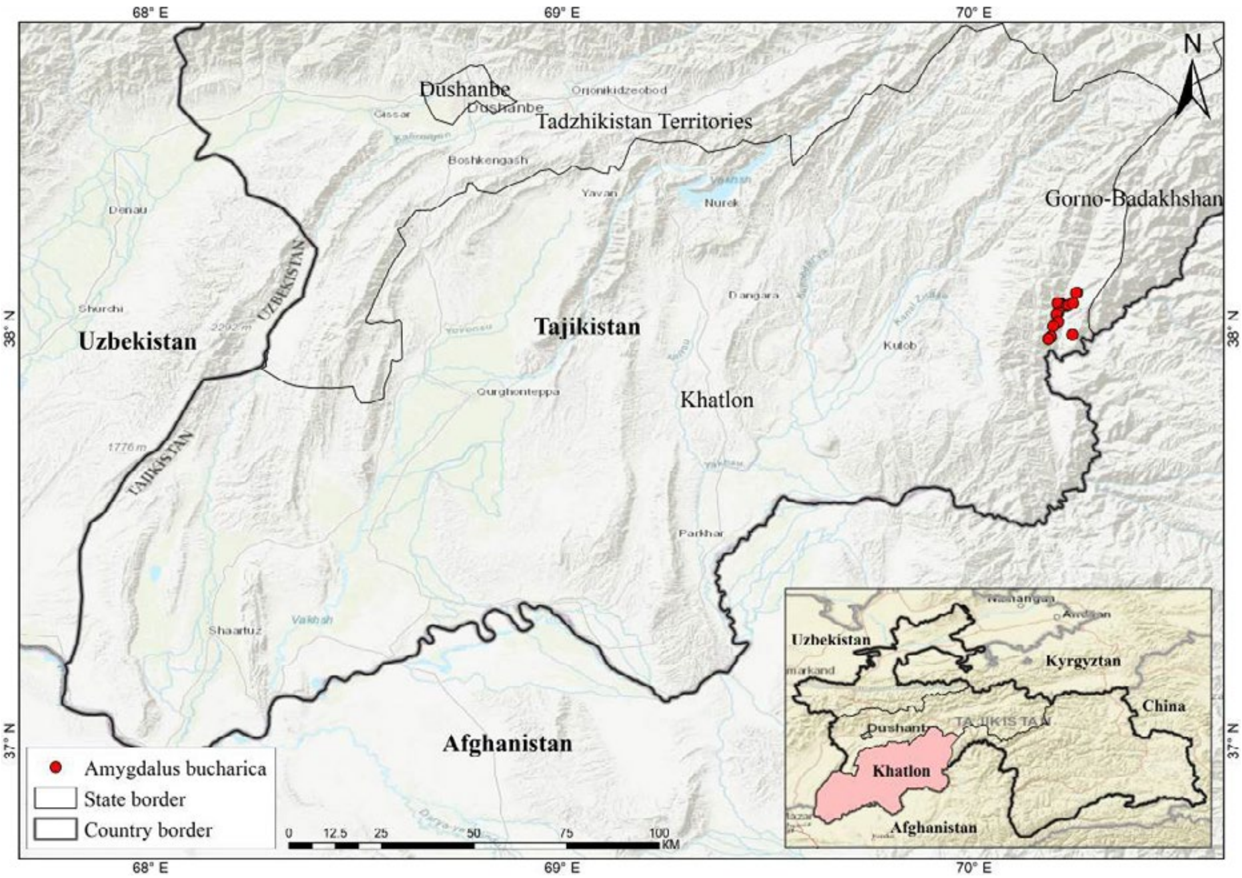
2020-2022. Six expeditions aimed at determining the state of the distribution area of endemic, rare, and endangered species of plants were conducted in Dashtijum village of Shamsiddin Shohin district. Furthermore, seeds and fruits of rare varieties of local and wild flora were collected to be grown in nurseries created in Dashtijum and Khasorak villages, including wild apple (*Malus siversii*), Bukharan pear (*Pirus bucharica*), Tajik pear (*Pyrus tadshikistanica*), and Vavilov's almond (*Amygdalus vavilovii*). As a result of the expeditionary botanical research in the Dashtijum zone, 60 reports on the species composition of wild woody fruits were compiled, indicating their phenological characteristics and exact locations on the studied territory (annex 1, paragraph 1.1.).

All studied populations are presented in Table 1, annex 1, paragraph 1.1., attached to the report.

***Amygdalus bucharica* Korsh.**

The studied wild populations of *Amygdalus bucharica* in the Kulob zone of Khatlon region are shown in Figure 1.

Figure 1. The studied wild populations of *Amygdalus bucharica* in the Kulob zone of Khatlon region



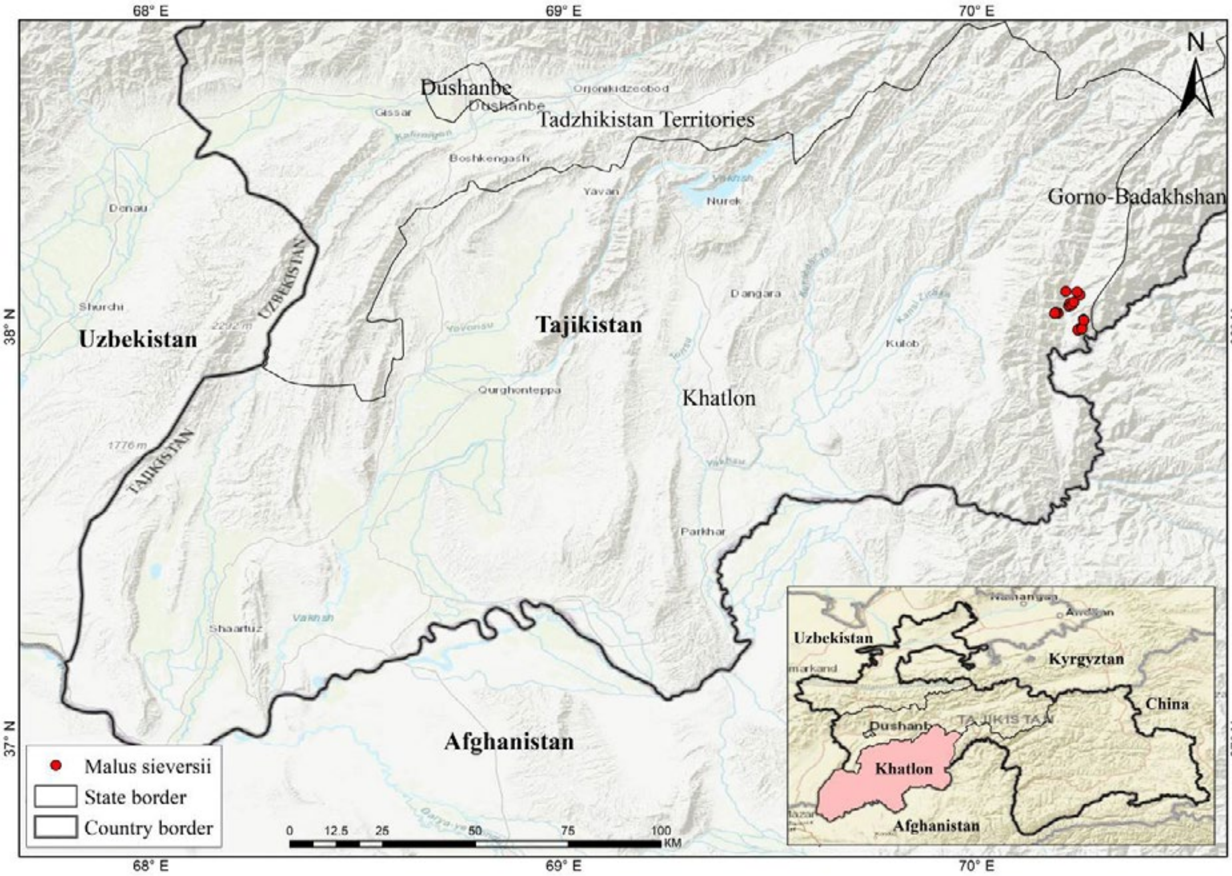
Amygdalus bucharica have a general distribution in the former Soviet Union (southeastern Turkmenistan, Uzbekistan, Tajikistan, and Kyrgyzstan) and northern Afghanistan.

***Ficus carica* L.**

Ficus carica in the Kulob zone of Khatlon region appears in the form of individual plants and forms populations, so we did not provide a map of the studied plants.

Malus sieversii **(Ledeb.) M. Roem.**
The studied wild populations of *Ficus carica* in the Kulob zone of Khatlon region are shown in Figure 2.

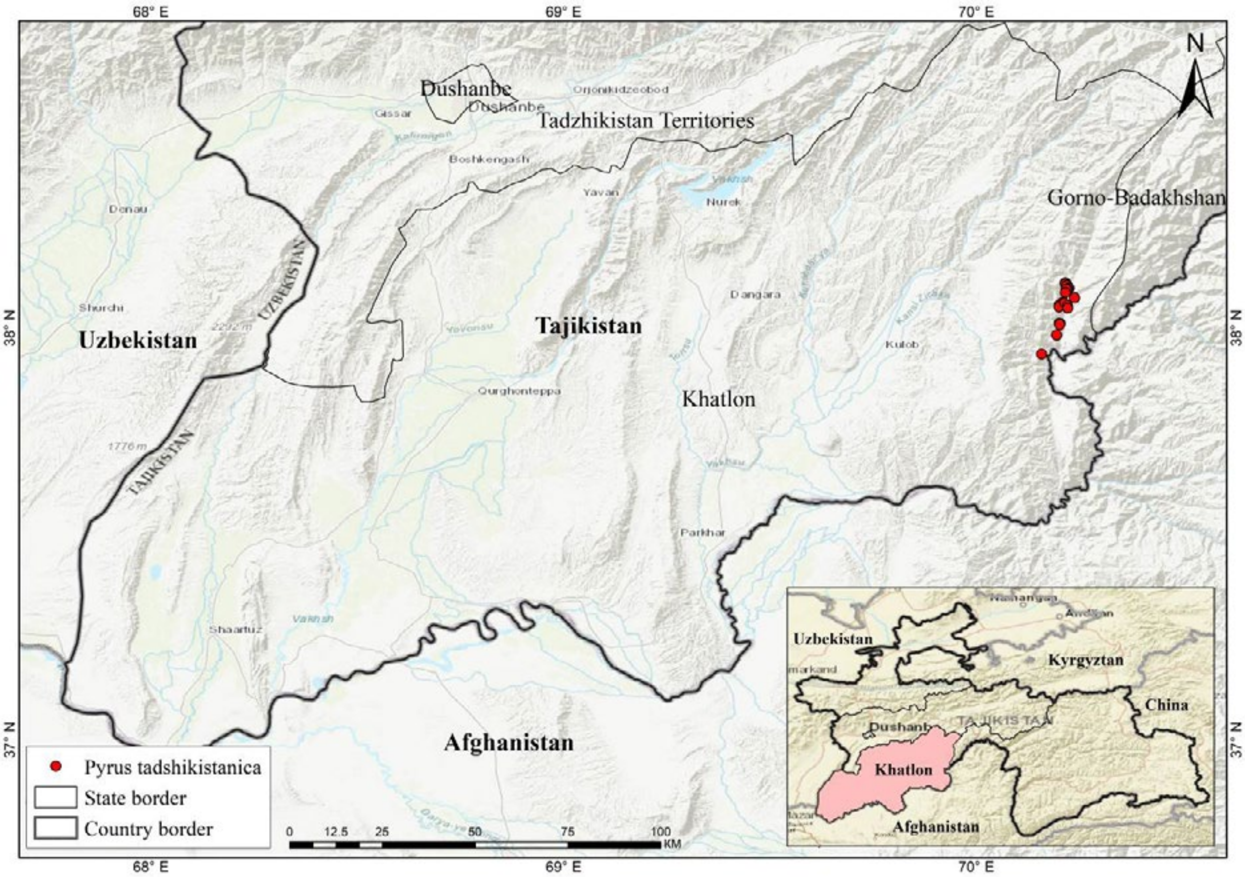
Figure 2. The studied wild populations of *Ficus carica* in the Kulob zone of Khatlon region



The current distribution of *M. sieversii* results from climatic changes during the most recent ice age. During this period, most of Central Asia was covered in ice, and the species could only survive in a number of isolated "refugia" that escaped the worst impacts. The distribution of the species today follows this same pattern; it is widespread but also highly fragmented and found in isolated forested areas in Central Asia (Tien Shan, Dzungarian Alatau, and Tarbagatai), northern Afghanistan, the southern Pamir-Alay mountain system, and the western Pamir mountains (Flora of the USSR, Nowak et al., 2018). In Tajikistan, *M. sieversii* grows throughout the country wherever there are fruit and nut forests. It is found in especially good numbers in: the southeastern part of Tajikistan, in Khatlon region; along the Varzy-Su River near the villages of Amrud, Iol, and Imam Askar; along the Ob-Surkh River, near the villages of God, Sarygor, Puli-Sangin, and Chorob; and on Surkhob Ridge, from the village of Baljuvon to the village of Khovaling.

Pyrus tadshikistanica **Zapr.**
The studied wild populations of *Pyrus tadshikistanica* in the Kulob zone of Khatlon region are shown in Figure 3.

Figure 3. The studied wild populations of *Pyrus tadshikistanica* in the Kulob zone of Khatlon

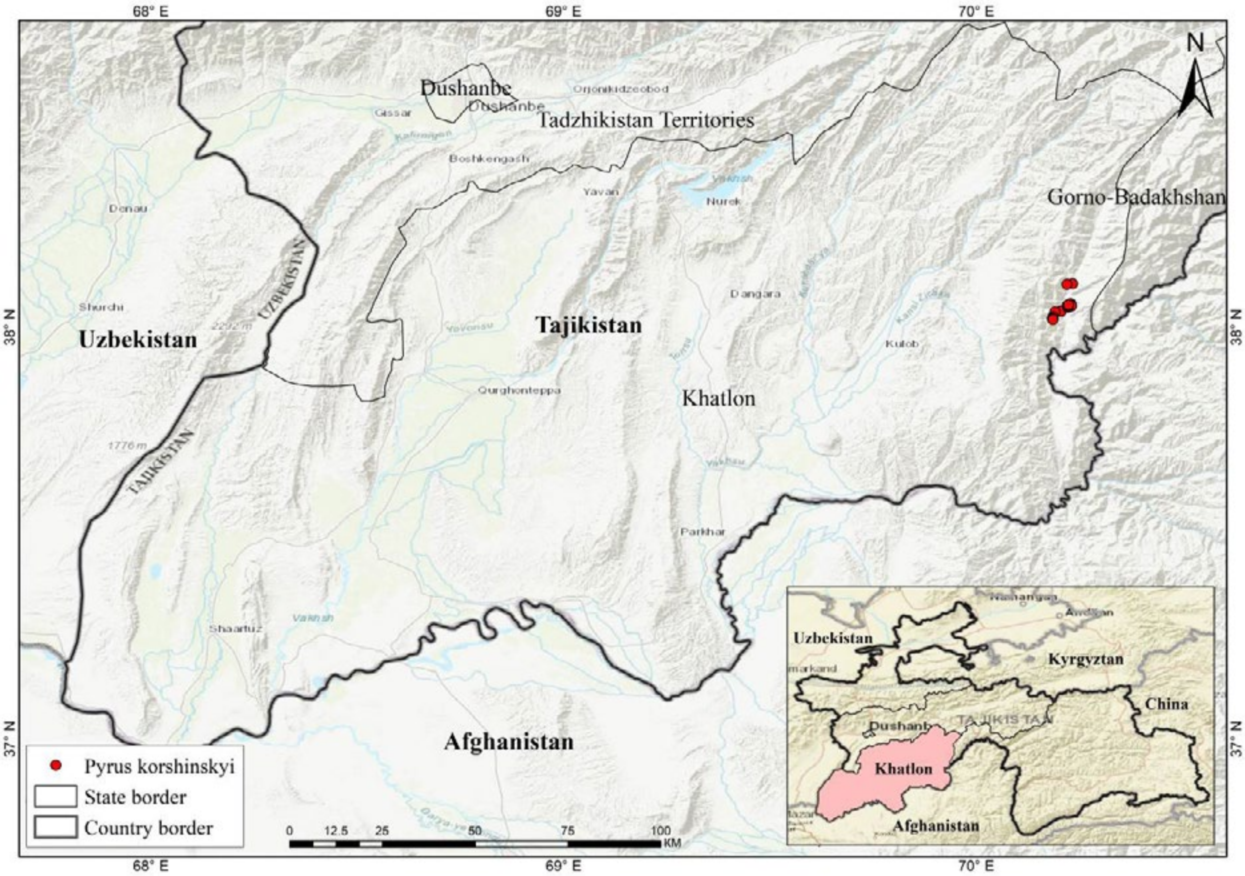


Pyrus tadshikistanica is endemic to Tajikistan, only found in the Pamir-Alay and Western Tien Shan. The local range of *P. tadshikistanica* extends throughout Tajikistan, especially on the lower and middle slopes of the Tien Shan and other mountain ranges in the region. It is found in Sary-Khosor, the Ob-Hingou River Gorge, the Obi-Niou River, the area of the Khur, Kavluch, and Hamm-Makhlyab villages, the basin of the Shurab-Dara River, Toit village, the surroundings of the Darai-Khauz village, between the villages of Dashti-Gulob and Hausoni, in the surroundings of Davlytabad, in the Vakhsh Ridge, and between Khovaling and Baljuvan.

***Pyrus korshinskyi* Litv.**

The studied wild populations of *Ficus carica* in the Kulob zone of Khatlon region are shown in Figure 4.

Figure 4. The studied wild populations of *Pyrus korshinskyi* in the Kulob zone of Khatlon region



This species is scattered across Central Asia (including the Pamir-Alay and Western Tien Shan mountain ranges) and northern Afghanistan. The majority of the population is found in the central regions of Tajikistan and Kyrgyzstan, found in forests together with *M. sieversii* at an altitude of 1,200-1,600 m. Recently, a new population was confirmed in a remote corner of Kyrgyzstan, in which about 100 mature trees were found (Fauna-flora.org, 2018). *Pyrus korshinskyi* has a fragmented distribution within Tajikistan's remaining deciduous forest, and is most commonly found in the Pamir-Alay and Western Tien Shan. This includes forest blocks in central and southern Tajikistan and in the Western Pamirs (Miravalova et al., 2018).

***Punica granatum* L.**

Pomegranate grows in gardens on the territory of the Kulob zone of Khatlon region, but natural populations have not been studied.

Pomegranate (*Punica granatum* L.) was one of the first domesticated fruits to be cultivated. It is indigenous to Iran and neighboring countries, and gradually developed into Central Asia regions and on to the Himalayas, the Eyalet of Anatolia, the Middle East, and the Mediterranean. It also thrives in Arizona and California, and has been cultivated in the Mediterranean region, South Asia, and the Middle Eastern countries. Meanwhile, Kandahar in Afghanistan is famous for its high-quality pomegranate. Today, the pomegranate is cultivated all over the world, including Iran, Spain, Italy, Afghanistan, the US, India, China, Russia, Uzbekistan, Morocco, and Greece. Iran is one of the biggest producers of pomegranate in the world with Markazi, Yazd, Fars, Khorasan, and Kerman provinces having the highest production rates in the country (Shaygannia et al., 2016).

4.3. Results of the Study of the State of Populations

As a result of the expeditionary botanical research on the territory of Dashtijum village, data on 40 habitats of rare and wild fruit trees were collected, including descriptions of their species composition, phenological characteristics, and exact locations. In the course of the study, it was discovered that the territory contains a wide variety of tree species. The researchers encountered over 50, including: Tajik pear – *Pyrus tadshikistanica*; Korjinsky pear – *Pyrus korshinskyi*; Bukharan almond – *Amygdalus bucharica*; Sievers apple – *Malus sieversii*; Cherry-plum – *Prunus sogdiana*; Turkestan maple – *Acer turkestanicum*; Regel maple – *Acer regelii*; Pontic hawthorn – *Crataegus pontica*; Griffith Judas-tree – *Cercis griffithii*; Pashtun juniper – *Juniperus seravshanica*; and walnut – *Juglans regia*.

In addition, Dashtijum is home to many endemic and rare wild plant species, including: Darvaz iris – *Iris darwasica*; Lined iris – *Iris lineata*; Juno iris – *Jun*o *rosenbachiana*; Tulip 'Fusilier' – *Tulipa praestans*; Maximovixh tulip – *T. maximowiczii*; Darvaz onion – *Allium darwasicum*; and Baldjuan knotgrass – *Polygonum baldshuanicum*. There are also many taxons used by humans among local plants, for instance, in medicine such as: Bird knotgrass – *Polygonum aviculare*; Turkestan Adonis – *Adonis turkestanicus*; Barberry – *Berberis heterobotrus*; Dog rose – *Rosa canina*; Licorice – *Glycyrrhiza glabra*; Elm-leaved sumac – *Rhus coriaria*; St. John's Wort – *Hypericum perforatum*; Sea buckthorn – *Hippophae rhamnoides*; Short-cup Ziziphora – *Ziziphora brevicalyx*; and Rose Charm – *Origanum tyttanthum*. There are also plants used in food, such as: Persian shallot – *Allium stipitatum*; Giant onion – *A. giganteum*; Maclean onion – *A. macleana*; Common onion – A. *Trautvetterianum*; Rosenbach onion – *A. rosenbachianum*; Black cumin– *Bunium persicum*; Violet ferula – *Ferula violacia*; Tajik ferula – *Ferula tadshikorum*; Fragrant wintergreen – *Galagania fragrantissima*; and Maximovich rheum – *Rheum maximoviczii*.

The full results of the population research are presented in annex 1, paragraph 2.

***Amygdalus bucharica* Korsh.**

The altitude limits of *Malus sieversii* on the territory of Dashtijum range between 1,250 m and 2,000 m a.s.l., but the plant is more commonly found within the altitudes of 1,400 and 1,900 m a.s.l. Only two locations of *Amygdalus vavilovii* were recorded on the test areas on the territory of Dashtijum. The state of the Vavilov almond population during the research was unsatisfactory. On the territory of Dashtijum, *Amygdalus vavilovii* is most commonly found on the slopes of the southwestern and southern exposures. Moreover, the research has shown that *Amygdalus vavilovii* is more widespread on the middle slopes of Darvaz Ridge. Taking into account the stand density in the test areas, it was determined that this species is rare. Indeed, there were only 1-3 *Amygdalus vavilovii* trees found in each area. A study of the amount of undergrowth in the test areas led to a conclusion that the species are extremely rare, as single specimens were barely found. Meanwhile, research into the age composition of the almond trees showed the presence of mixed populations with specimens of various ages. Livestock-caused damage was practically non-existent, but key threats to the population, in our opinion, are climate change, dry summer seasons, and logging carried out by local communities. According to our data, there are approximately 50 fruit-bearing trees and nearly 200 saplings in the territory.

***Ficus carica* L.**

Natural populations of *Ficus carica* are presented as single specimens in the Kulob zone of Khatlon region; they are rare and, thus, *all* locations were noted.

Malus sieversii **(Ledeb.) M. Roem.**
Malus sieversii is found on the territory of Dashtijum at altitudes between 1,250 and 2,000 m a.s.l.; however, they are more commonly present within the altitudes of between 1,400 and 1,900 m a.s.l. In total, 12 locations of *Malus sieversii* were recorded in test areas on the territory of Dashtijum. The state of the Sievers apple population was determined as satisfactory. In addition, on the territory of Dashtijum, *Malus sieversii* is more commonly found in the northwestern part (point 8), with 1-2 locations recorded in the other exposures. Research has shown that *Malus sieversii* populations prefer the upper (point 6) and middle (point 4) slopes of Vaksh Ridge, while, along the crest of the ridge, the plant is only found in two locations. A study of the stand density concluded that the species at point 8 is rarely found, while, at point 2, the stand is denser. Specifically, 1-12 Sievers apple trees were recorded at each point. Furthermore, most locations have little undergrowth (1-10 saplings at 10 points), which constitutes 83% of the total quantity of saplings in the test areas. Two test areas had over 10 saplings. In terms of age composition, the study showed that, at point 5, there was an absence of young specimens, while point 6 contained mixed ages (both young and old specimens were present). Some damage of Sievers apple trees caused by livestock was recorded on the territory of Dashtijum.

According to our research, there are over 6,000 fruit-bearing trees and approximately 300 saplings on the studied territory. Key threats and limiting factors are tree cutting, tree removal for the purposes of rootstock propagation, and livestock grazing.

Pyrus tadshikistanica **Zapr.**
We determined the state of the *Pyrus tadshikistanica* population to be unsatisfactory. Specifically, on the territory of Dashtijum, Tajik pear is found at point 17, in the Mirkwood belt, and along the upper limits of the siblyak (shrub) belt. Meanwhile, *Pyrus tadshikistanica* is more common on the northwestern (point 10) and southwestern (point 5) slope exposures. Only one location was recorded on other exposures, while, on the northern and southern slopes, no Tajik pear trees were found at all. The research showed that *Pyrus tadshikistanica* is more common within the middle (point 12) and lower (point 5) altitude limits of the Khazratishokh Ridge, but absent within the upper limits and along the ridge. The study concluded that the stand density of the species is not particularly high, with each location having 1-5 trees. Only one location (h-1524 м; 38°06'76.2''N, E70°14'46.3''E) had 15 trees growing there, the medium height of which was 3 m and the medium stand of which was150 mm in diameter. In this location, *Pyrus tadshikistanica* trees form a dense stand spacing, while, in other locations, the spacing is medium (point 4) or scarce (point 12). A study of the state of the undergrowth in the test areas concluded that, in most places, it is non-existent or insubstantial (point 11). Two locations had 50-150 saplings, which are root offspring, while we did not record seed reproduction. With regard to age composition of the trees, the study showed that there are young and old specimens growing at point 5 (mixed population) and point 9 had no young trees. Pear trees damaged by livestock were recorded all over the studied territory.

On the territory of Dashtijum, *Pyrus tadshikistanica* is mainly reproduced by vegetative means. However, the research did not find any evidence of seed reproduction. On the territory of Dashtijum, *Pyrus tadshikistanica* is typically found at altitudes of 1,170-1,700 m a.s.l., and is especially common within altitudes of 1,200-1,500 m a.s.l., on the northwestern and southwestern slopes. Naturally, Tajik pear grows near such plants as Turkestan maple – *Acer turkestanicum*, Regel maple – *Acer regelii*, Hawthorn pontica – *Crataegus pontica*, Large-flowered calophaca – *Calophaca grandiflora*, Bukharan almond - *Amygdalus bucharica*, and pistachio – *Pistacia vera,* and most commonly in the grass cover of Yugan – *Prangos pabularia*, Wild Asafoetida – *Ferula jaeschkeana*, Bulbous barley – *Hordeum bulbosum*, licorice – *Glycyrrhiza glabra*, and Elecampane – *Inula grandis*.

We observed that *Pyrus tadshikistanica* is often used in old gardens on the territory of Dashtijum. Moreover, old trees can still be found in Shoinak, Khami Makhlab, and Okhangaron villages. Notably, *Pyrus tadshikistanica* is included in the Red Book of Central Asia.

According to preliminary estimates, up to 300 fruit-bearing trees and over 2,000 saplings may have grown as a result of vegetative reproduction. However, new we did not record a single case of seed reproduction on the examined territory. Pertinently, the populations of this endemic pear variety are fragmented and small in number and threatened by tree-cutting, extensive cattle grazing, and the uprooting of trees for the purpose of clearing the land to satisfy economic needs.

***Pyrus korshinskyi* Litv.**
On the territory of Dashtijum, *Pyrus korshinskyi* is found at altitudes of 1,250-1,900 m a.s.l., most commonly within altitudes of 1,500-1,700 m a.s.l. Naturally, *Pyrus korshinskyi* grows near such plants as Turkestan maple – *Acer turkestanicum*, Tajik poplar – *Populus tadshikistanica*, Hawthorn pontica – *Crataegus pontica*, Large-flowered calophaca – *Calophaca grandiflora*, Pashtun juniper – *Juniperus seravshanica*, Sievers apple – *Malus sieversii*, Mahaleb cherry – *Padellus mahaleb*, and among such shrubs as Honeysuckle – *Lonicera nummulariifolia* and Kokand wild-rose – *Rosa kokanica*. Meanwhile, the grass cover consists predominantly of Yugan – *Prangos pabularia*, Mountain pea – *Thermopsis dolichocarpa*, Wild Asafoetida – *Ferula jaeschkeana*, Catnip – Nepeta podastachys, and Rose Charm – *Origanum tyttanthum*.

In total, there were nine test areas in which *Pyrus korshinskyi* was recorded on the territory of Dashtijum. In particular, Korjinsky pear is found in the belts of Mirkwood, most commonly on the slopes of the northwestern (point 5), western (point 3), and northeastern (point 1) exposures. We were unable to find a single specimen on any other exposures. Moreover, the research showed that *Pyrus korshinskyi* trees are more commonly found within the middle (point 5) and upper (point 2) altitude limits, as well as along the crest of the ridge. Ultimately, the study concluded that the state of the population of the Korjinsky pear is unsatisfactory. In particular, the research on the stand density showed that the species is rare in the test areas (point 8): each area had 1-2 *Pyrus korshinskyi* trees. Additionally, the undergrowth is either non-existent or represented by single specimens only (point 8). In just one location were there more than 10 saplings that grew as a result of vegetative reproduction. Meanwhile, seed reproduction is determined to be rare. Regarding age composition, the research concluded that there are very few young trees (point 5). Currently, the Korjinsky pear population comprises old trees, and natural reproduction is challenging.

According to our observations, there are 350 fruit-bearing trees and no more than 200 saplings of Korjinsky pear on the territory of Dashtijum, which indicates a critically low stand density. Livestock-caused damage was not observed, but key threats to the population are improper use of pastures and uprooting of saplings for the purpose of propagating domesticated pear varieties in residential gardens.

***Punica granatum* L.**
Populations of *Punica granatum* were found in Dashtijum, Darvaz, and Varzob, but these were not studied.

4.4. Organization of Tree Nurseries

2020-2022

Two fruit tree nurseries were created in Dashtijum and Khasorak villages in Shamsiddin Shohin district, with the help of local communities. Meanwhile, seeds were planted after soil preparation, which took place at the beginning of April. In addition, stratification of the collected materials for planting was conducted.

1. Fayzali Sharifov's nursery is located in Dashtijum village (38°01'26.8"N, 70°12'52.2"E). On its 0.03 hectare territory, the nursery grows saplings of a wide variety of fruit trees, including apricot, pear, apple, almond, fig, and pomegranate. In their first year, the nursery's saplings showed good growth.
2. Currently, Sharifov's nursery is home to over 2,000 saplings, 100 of which are apricot, 230 are pear, 350 are apple, 50 are almond, 120 are fig, and 1,200 are pomegranate. By the end of October each year, the height of fruit saplings ranged between 50 cm and 180 cm (annex 1, fig. 8).
3. A diagnosis of the state of Safarali Begov's nursery was conducted in Khirasok village (38°02'09.7"N, 70°12'54.2"E). Seeds of apple, pear, apricot, walnut, and almond were planted on its 0.05 hectare territory. Additionally, cuttings of pomegranate and fig were planted in the nursery with the goal of further distribution among the local community and creation of fruit gardens aimed at the preservation of endemic varieties. The state of the nursery fully meets agricultural requirements.

Safarali Begov's nursery is home to approximately 3,000 saplings, 350 of which are apricot, 250 are pear, 400 are apple, 50 are almond, 100 are fig, and 1,800 are pomegranate. By the end of October of each year, the height of the fruit saplings ranged between 50 cm and 220 cm (annex 1, fig. 9).

During the reporting period, some saplings of apple, pear, pomegranate, and apricot were dug out in early December 2021 and subsequently sold (annex 1, fig. 10).

Budding was conducted in late July and August 2021 in the nurseries of Dashtijum. Prior to the start of this process, the lateral branches on the lower part of the stems of budsticks were removed. Budding was carried out as follows: using a sharp knife, a piece of the bark was cut from the stem of the budstick (no less than 2.5 cm in length and had a thin sliver of wood); the bud shield was then carefully inserted into a T-shaped cut of the rootstock bark, made on its northern side, close to the root neck; after that, the site of contact was tightly wrapped with soft polyethylene tape, leaving the bud open. In 15-20 days, it was checked whether the buds have taken (annex 1, fig. 11).

At a later phase, when two buds broke, the stronger shoot was left, while the other was cut. Preference was given to shoots that grew from the northern side of the rootstock.

The two nurseries in Dashtijum have become commercial businesses, selling fruit trees to local markets. They also play a vital role in the preservation of wild trees and help to spread the fruit species and the varieties they grow all over Dashtijum. Moreover, the farmers working in the nurseries benefit economically from selling saplings at local markets. Previously, communities living in Dashtijum bought fruit rootstocks for their gardens from the market located in Kulob and their nurseries in the districts of Khamadoni and Vos. According to the experience of local farmers, fruit saplings from those nurseries would sometimes be contaminated with several pathogens causing the plants to die within 7-10 years. Furthermore, some of these saplings carried infectious agents and diseases, infecting and killing other fruit trees on the territory of Dashtijum.

The creation of nurseries in Dashtijum has, thus, limited the spread of infections and diseases among fruit trees. Moreover, they allow farmers to obtain healthy saplings that bear organic and delicious fruits.

4.5. Local Unnamed Varieties and Recommendations for Patenting

According to H. N. Nazirov (2011), there are 220 local and 600 wild varieties of Sievers apple growing in various eco-geographical zones of Tajikistan. Nine isolated populations of Sievers apple were identified, which, depending on their ecological environments, differed in polymorphism, morphological, and biological characteristics. The populations were found in the following locations: (1) Ramit; (2) Fayzabad; (3) Karategin; (4) Karatag; (5) Varzob; (6) Zeravshan; (7) Muminabad; (8) Dashtijum; and (9) Darvaz. These varieties all have a great potential value for selection and production and, therefore, should be patented.

According to H. M. Akhmadov et al. (2010), currently, a large collection of pomegranate varieties and forms in Tajikistan are located at the research station for subtropical plants at the Institute of Horticulture and Vegetable of the Tajik Academy of Agricultural Sciences in the district of Djami Rumi, as well as at the base of the Pamir Biological Institute under the Academy of Sciences of the Republic of Tajikistan at the Zigar site in Darvaz district. The most promising varieties have been submitted for government testing. Earlier, in 1959, a soft-seeded variety of pomegranate was bred, which later became known as the “Dessert” variety. Among the various studied varieties in the collection, a promising clone, Kzyl-anor 10/15, and form 08P were identified, which were then propagated and planted for further testing. The availability of a large and fairly diverse range of pomegranate varieties in Tajikistan results from the exceptional work of the country’s horticulturalists. The State Commission for Variety Testing and Protection of Agricultural Crops under the Government of the Republic of Tajikistan has zoned different varieties of pomegranate, such as Achik-dona, Dessert, Kazake-anor, Kzyl-anor, and Azerbaijan (fig. 2). In 2009, the Government of Tajikistan adopted a program for planting orchards and vineyards on an area of 46,900 hectares. The plans under this program included the creation of orchards of the best varieties of pomegranates in southern Tajikistan, particularly in the Vakhsh Valley, on an area of at least 2,500 hectares, where natural and climatic conditions meet the biological requirements of this crop.

4.6. Training Farmers

In the course of the project, the following activities were carried out for farming communities, the local population, and forestry workers:

1. 2-6 April 2020. Organization of a workshop aimed at identifying the use of wild species and their landraces in local communities and collecting information.
2. 10-20 June 2020. Consulting and organizing in preparation for the establishment of nurseries using local varieties based on wild species.
3. 10-20 June 2020. Conducting seminars with the participation of fruit tree experts and providing practical training.
4. 15 January 2021. Preparing the original layout of the following methodological manuals: S.M. Gulov, M.T. Boboev, A.K. Namozov, R.S. Nabotov Horticulture [Bohparvary], Dushanbe. P. 35. (Edition 11/20/2021).
5. 10-20 February 2021. Organization of nurseries based on the local climate, preparation of sites, and supplying local communities with the necessary materials and equipment.
6. 12-30 September 2021. Annual monitoring of nurseries, issuing scientific advice on identifying errors, and optimizing the cultivation of planting material.
7. 2020-2021. Working with forestry departments, local authorities, and educational institutions.

Recommendations

Recommendations for local farming communities

For the effective conservation and restoration of plants, a number of recommendations are proposed for each species.

1. Implement better control of livestock grazing so that animals are kept far away from trees.
2. Protect the most valuable trees with metal meshes.
3. Create restoration sites for the planting of seedlings.
4. Prohibit and eliminate logging.
5. Prohibit and eliminate the uprooting of young trees.
6. Develop a restoration system by means of seed propagation.

Recommendations for local government agencies (forest department, environment protection committee)

1. Preservation of the habitat of wild relatives of cultivated plants, maintenance of natural habitats, and stabilization of plant communities, which are the components of biological diversity.
2. Development and dissemination of molecular genetic approaches for a more complete unlocking of the potential of wild relatives of cultivated plants, as well as tools for their conservation.
3. Observation and protection in state national natural parks. In cases of endangered species, ex situ conservation is necessary.
4. Creation of germplasm banks and subsequent reintroduction from ex situ into natural habitats, making it possible to restore damaged ecosystems and beneficial genotypes of wild relatives of cultivated fruit trees.
5. Reintroduction and introduction of species useful in their new habitats for erosion control, phytomelioration, and reclamation of degraded lands, forest plantations, as fodder species, ornamental plants, etc.
6. Preservation of plant communities, since communities are the defining component of ecological systems.
7. Creation of collections, seed banks, preservation and distribution in scientific institutes, botanical gardens, and local communities.
8. Use remote sensing of landscapes. Graphical visualization of spatial (geographical) data allows mapping and monitoring habitats of sensitive species, comparing them with protected and undisturbed habitats.
9. Study the genetic diversity and molecular taxonomy of plants. Barcoding is used based on universal DNA markers of the nuclear and chloroplast genomes.
10. Monitor the state of populations. All demographic data must be available online; the regenerative capacity of stored samples should be assessed to ensure long-term use; and all material should be duplicated in geographically separated gene banks.

Recommendations for scientific institutions

1. Create exhaustive collections of wild relatives. They should be phenotyped according to traits that are a priority for cultural representatives and reflect spatial and ecological diversity that provides adaptive variability.
2. Sequence the genomes of wild relatives for the purpose of subsequent “construction of functional sets” enriched with adaptive alleles of populations.

3. Purposefully create and phenotype hybrid populations.
4. Develop predictable genotype-phenotype associations. Genotype-phenotype mapping to identify areas of the genome and genes of wild species can increase the potential of cultivated species.
5. Apply the relevant identified phenotypes to improve the elite cultural genotypes.

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Annex

1.1. Descriptions of the species composition of wild-growing woody fruits in the Dashtijum zone, indicating their phenological characteristics, as well as their discovery locations in the studied area (results from 2020).

Description № 1. *Pyrus bucharica* Litv. subsp. daschtidshumica Zapr. (shaking, murudi dashti)
Location: h-1232 м; 38°02'36.5"N, 70°12'3.6" E
Area: The basin of the Obiniob River. Above the village of Khasoraki Bolo.
Vegetation type: Shiblyak.
Development phase: End of fruiting period.
Quantity and stand density: 3 trees on an area of 1 hectare.
Seed reproduction: Rarely observed.

Description № 2. *Juglans regia L.* (walnut)
Location: h-1329 м; 38°02'36.0"N, 70°12'21.2"E
Area: The basin of the Obiniob River, above the village of Khasoraki Bolo.
Vegetation type: Mirkwood.
Development phase: During the fruiting period.
Quantity and stand density: Approximately 12 trees on an area of 1 hectare. The average height is 9 m, while the trunk circumference ranges between 13 and 68 cm.
Seed reproduction: None observed.

Description № 3. *Pyrus bucharica* Litv. Subsp. Daschtidshumica Zapr. (Shaking, murudi dashti)
Location: h- 1320 м; 38°02'33.7"N, 70°12'34.2"E
Area: The basin of the Obiniob River, above the village of Khasoraki Bolo.
Vegetation type: Shiblyak.
Development phase: During the fruiting period.
Seed reproduction: None observed.

Description № 4. *Malus sieversii* (Ledeb.) M. Roem. Variety Barzangiseb (Sebi changali)
Location: h-1607 м; 38°02'01.5"N, 70°11'79.2"E
Area: The basin of the Obiniob River, Khazratisho Reservoir, and southwestern exposure.
Vegetation type: Shiblyak.
Development phase: Fruiting period.
Quantity and stand density: 1 tree on an area of 1 hectare.
Seed reproduction: None observed.

Description № 5. *Malus sieversii* (Ledeb.) M. Roem. (Sebi changali)
Location: h- 1683 м; 38°02'12.3"N, 70°11'45.2"E
Area: The basin of the Obiniob River, Khazratisho Reservoir, and southwestern exposure.
Vegetation type: Shiblyak.
Development phase: Fruiting period (Fig. 1).
Quantity and stand density: Approximately 6 trees on an area of 1 hectare.
Seed reproduction: None observed.

Figure 1. Malus sieversii fruits

Description № 5. *Pyrus bucharica* Litv. subsp. daschtidshumica Zapr. (Shaking, murudi dashti)
Location: h-1718 м; 38°02'20.7''N, 70°11'41.8''E
Area: The basin of the Obiniob River, Khazratisho Reservoir, northeastern exposure.
Vegetation type: Shiblyak.
Development phase: Fruiting period (Fig. 2).
Quantity and stand density: Approximately 2 trees on an area of 1 hectare.
Seed reproduction: None observed.
Vegetative reproduction: None observed.

Figure 2. Pyrus bucharica Litv. subsp. daschtidshumica Zapr. fruits

Description № 6. Malus sieversii (Ledeb.) M. Roem. (Sebi changali) (Fig. 3)
Location: h- 1717 м; 38°01'96.2''N, 70°11'31.9''E
Area: The basin of the Obiniob River, Khazratisho Reservoir, and northeastern exposure.
Vegetation type: Shiblyak.
Development phase: Flowering period.
Quantity and stand density: Approximately 4 trees on an area of 1 hectare.
Seed reproduction: none observed.

Description № 7. *Crataegus pontica* C. Koch in Verh. (dulona)
Location: h-1717 м; 38°01'96.2''N, 70°11'31.9''E
Area: The basin of the Obiniob River, Khazratisho Reservoir, above Devlokh village, and northeastern exposure.
Vegetation type: Shiblyak.
Development phase: Fruiting period.
Quantity and stand density: Approximately 9 trees on an area of 1 hectare.
Seed reproduction: None observed.

Description № 8. *Prunus darvasica* Temb. (olucha, argandjol)
Location: h- 1717 м; 38°01'96.2''N, 70°11'31.9''E
Area: The basin of the Obiniob River, Khazratisho Reservoir, above Devlokh village and northeastern exposure.
Vegetation type: Shiblyak.
Development phase: Flowering period.
Quantity and stand density: Approximately 5 trees on an area of 1 hectare.
Seed reproduction: None observed.

Description № 9. *Pyrus bucharica* Litv. subsp. daschtidshumica Zapr. (Shaking, murudi dashti)
Location: h-1398 м; 38°06'32.4''N, 70°13'98.5''E
Area: The basin of the Obiniob River, Darvazsky Reservoir, above Yakhsho village, and northeastern exposure.
Vegetation type: Mirkwood, single trees of cherry plum – Prunus sogdiana, wild grape – *Vitis vinifera*, hawthorn – *Crataegus pontica*, barberry – *Berberis heteropoda*, wild rose - *Rosa canina,* and walnut – *Juglans regia,* while other species are also present.
Development phase: Fruiting period.
Quantity and stand density: Approximately 3 trees on an area of 1 hectare.
Seed reproduction: None observed.
Vegetative reproduction: None observed.

Description № 10. *Pyrus tadshikistanica* Zapr. (Murud, andjirak)
Location: h-1403 м; 38°06'37.9''N, 70°13'95.6''E
Area: The basin of the Obiniob River, Darvazsky Reservoir, above Yakhsho village, and northeastern exposure.
Vegetation type: Mirkwood.
Development phase: Fruiting period.
Quantity and stand density:
Seed reproduction: None observed.

Description № 11. *Pyrus tadshikistanica* Zapr. (Murud, andjirak)
Location: h-1503 м; 38°06'69.6'N, 70°14'39.6''E
Area: The basin of the Obiniob River, Darvazsky Reservoir, above Yakhsho village, and northeastern exposure.
Vegetation type: Shiblyak, single trees of cherry plum - *Prunus sogdiana*, hawthorn – *Crataegus pontica*, barberry – *Berberis heteropoda, Padelus magaleb,* while other species are also present.
Development phase: Fruiting period.
Quantity and stand density: Approximately 2 trees per 1 hectare, with the trees' height reaching 5 m and the trunk circumference up to 57 cm.

Seed reproduction: None observed.
Vegetative reproduction: None observed.

Description № 12. *Pyrus tadshikistanica* Zapr. (Murud, andjirak)
Location: h-1524 м; 38°06’76.2”N, E70°14’46.3”E
Area: The basin of the Obiniob River, Darvazsky Reservoir, above Yakhsho village, and northeastern exposure.
Vegetation type: Shiblyak.
Development phase: Fruiting period (Fig. 4).
Quantity and stand density: Approximately 38 trees on an area of 1 hectare.
Seed reproduction: None observed.
Vegetative reproduction: 1-6 specimens observed on an area of 1 m^2.

Figure 3. Pyrus tadshikistanica Zapr. fruits

Description № 13. *Pyrus tadshikistanica* Zapr. (Murud, andjirak)
Location: h-1533 м; 38°06’80.4”N, 70°14’50.7”E
Area: The basin of the Obiniob River, Darvazsky Reservoir, above Yakhsho village, and northeastern exposure._
Vegetation type: Shiblyak.
Development phase: Flowering period.
Quantity and stand density: Approximately 2 trees on an area of 1 hectare.
Seed reproduction: None observed.
Vegetative reproduction: None observed.

Description № 14. *Pyrus tadshikistanica* Zapr. (Murud, andjirak)
Location: h-1483 м; 38°06’77.4”N, E70°14’36.9”N
Area: The basin of the Obiniob River, Darvazsky Reservoir, above Yakhsho village, and northeastern exposure._
Vegetation type: Shiblyak.
Development phase: Flowering period.
Quantity and stand density: Approximately 1 tree on an area of 1 hectare.
Seed reproduction: None observed.
Vegetative reproduction: No coppice shoots observed.
Description № 15. *Juglans regia* L. (chormagz, chormakhs)

Location: h- 1420 м; 38°06’61.6”N, 70°14’09.5”E
Area: The basin of the Obiniob River, Darvaz Ridge, and northeastern exposure.
Vegetation type: Mirkwood, single trees of cherry plum - *Prunus sogdiana*, hawthorn – *Crataegus pontica*, and Tianshan ash – *Fraxinus sogdiana* while other species are also present.
Development phase: Fruiting period.
Quantity and stand density: Approximately 5 trees on an area of 1 hectare, with trees’ height reaching 15 m, and the trunk circumference up to 128 cm.
Seed reproduction: None observed.

Description № 16. *Amygdalus vavilovii* M. Pop. (bodomi shirindona)
Location: h- 1852 m; N- 38^{0}05΄19”0; E- 070^{0}14΄51”9.
Area: The basin of the Obiniob River, Darvaz Ridge, Sarireg village, southwestern exposure, and Abdussator Gafforov’s house.
Vegetation type: Mirkwood.
Development phase: fruit ripeness.
Quantity and stand density: Approximately 6 trees on an area of 1 hectare, with the trees’ height reaching between 7 and 11 m, and the trunk circumference between 7 and 11 cm.
Seed reproduction: None observed.

Description № 17. *Ficus carica* L. (anchir)
Location: h- 1310 m; 38°05’96.3”N, 70°13’70.0”E
Area: The basin of the Obiniob River, Darvaz Ridge, Lou village, and southwestern exposure.
Vegetation type: Shiblyak.
Development phase: Fruiting period.
Quantity and stand density: Approximately 4 specimens on an area of 1 hectare.
Seed reproduction: None observed.

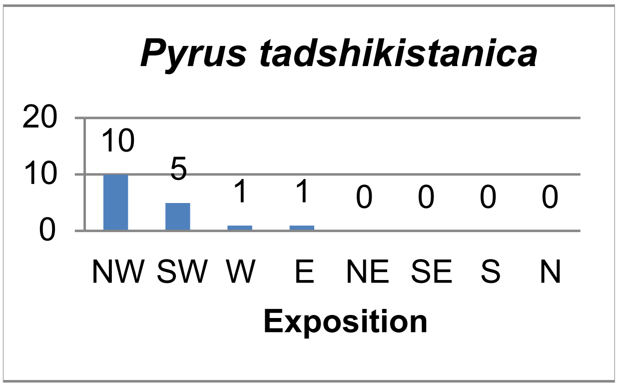
Description № 18. *Ziziphus jujuba* Mill. (chelon)
Location: h-1308 м; 38°05’24.6”N, 70°13’18.6”E
Area: The basin of the Obiniob River, Khazratisho Ridge, and southwestern exposure.
Vegetation type: Shiblyak.
Development phase: Fruiting period.
Quantity and stand density: Over 350 trees on an area of 1 hectare, with trees’ height reaching 2-4 m, and the trunk circumference up to 15-33 cm.
Seed reproduction: None observed.

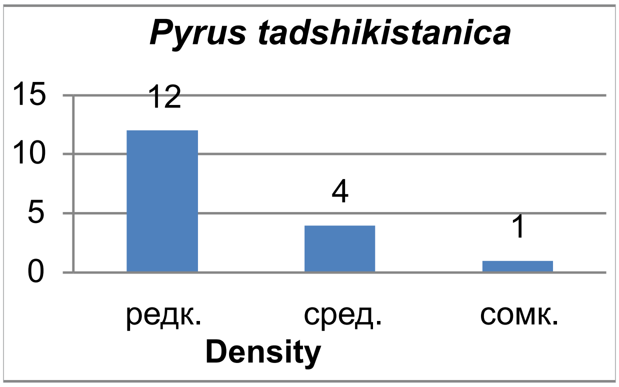
Description № 19. *Prunus darvasica* Temb. (olucha, arganjol).
Location: h- 1377 m; N- 38^{0}05’33”4; E- 070^{0}13’08”4.
Area: The basin of the Obiniob River, Khazratisho Ridge, between Kavlyuch and Khami Makhlab and northeastern exposure.
Vegetation type: Shiblyak.
Development phase: fruit ripeness.
Quantity and stand density: Approximately 25 shrub trees on an area of 1 hectare, at heights of 1.5-2.5 m, and the trunk circumference of 8-12 cm.
Seed reproduction: None observed.

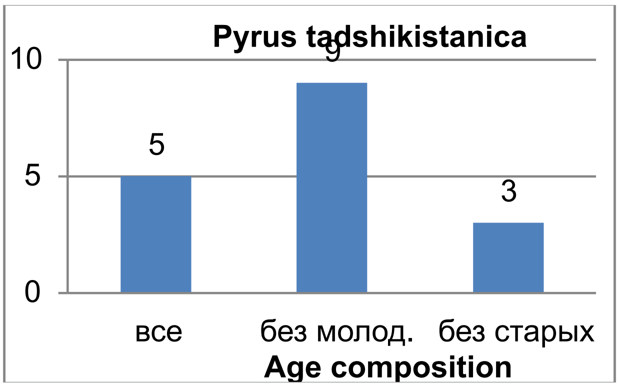
Figure 4. Prunus darvasica *Temb.*

1.2. Population Structure of the Fruit Trees

Figure 5. Population structure of Pyrus tadshikistanic







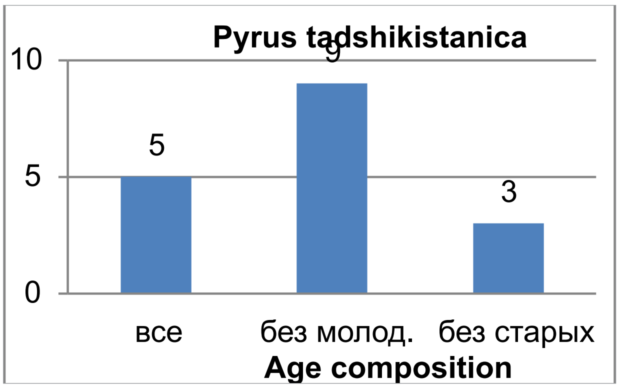


Figure 6. Population structure of Pyrus korshinskyi

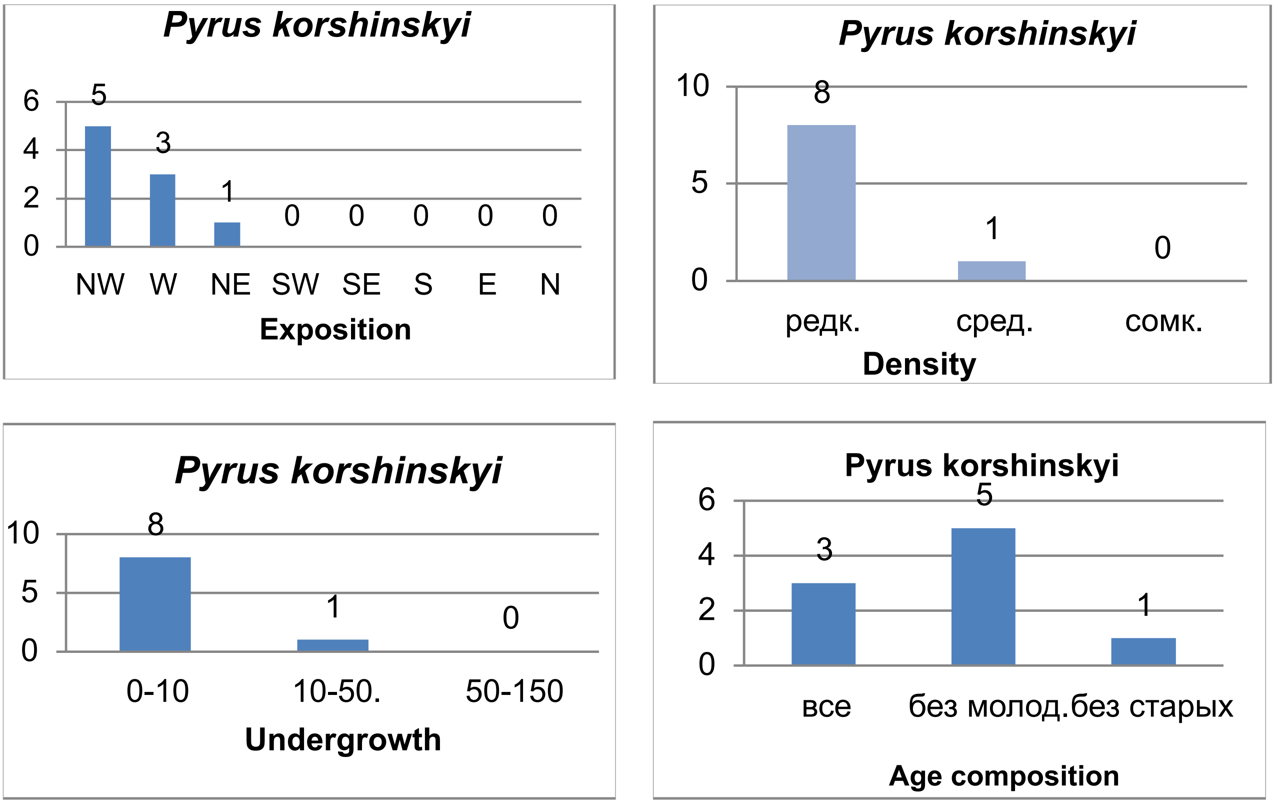


Figure 7. Population structure of Malus sieversii

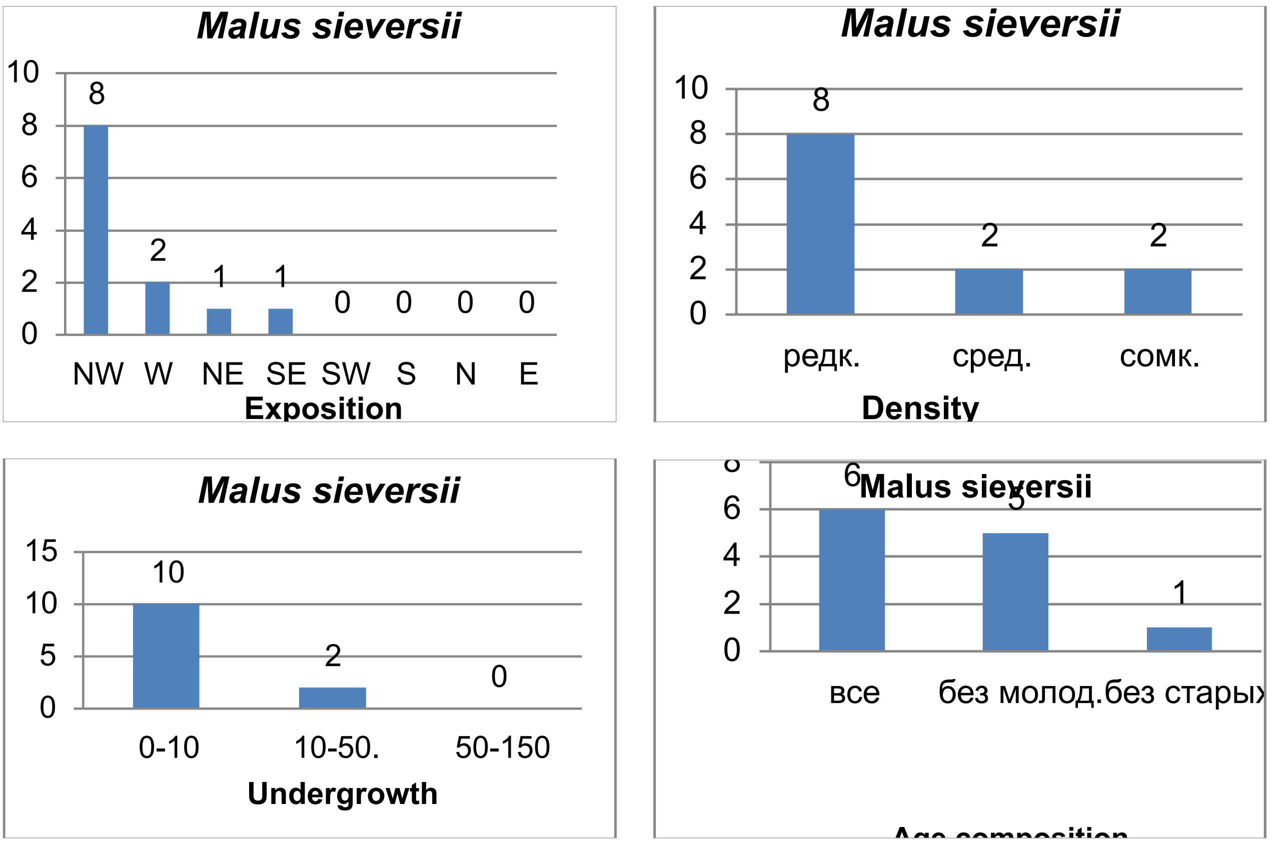


Figure 8. Fayzali Sharifov's nursery, Dashtijum village

Figure 9. Safarali Begov's nursery, Dashtijum village

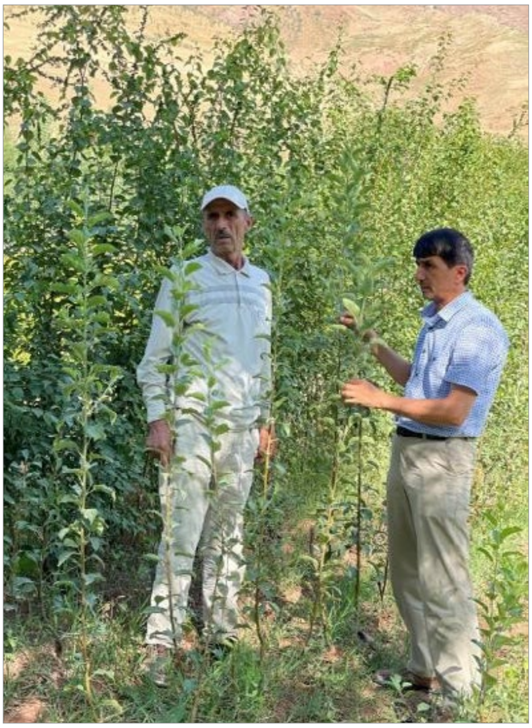


Figure 10. Digging out apple saplings in Safarali Begov's nursery

Figure 11. Grafting of the seldlings in nurseries

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