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Study of Natural Regeneration of Sogdian Ash (Fraxinus Sogdiana Bunge) and Silvicultural Measures to Promote it in the Sharyn River Floodplain of Almaty Region

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Abstract: The forests of Kazakhstan, and in particular the ash riparian forests of the Charyn National Nature Park, as part of the unique natural complexes of Almaty region, have special ecological, historical, scientific, aesthetic and recreational value. Moreover, the fraxinus sogdiana trees in the Charyn Ash Dacha are relict and specially protected. Against the background of increasing anthropogenic impact, general aridisation of ecosystems and xerophytisation of vegetation cover, preservation and restoration of these stands of trees is becoming a problem not only for the region, but also for the whole country. All this forms the relevance of the study.The purpose of the study was to investigate the regularities and characteristics of natural regeneration of fraxinus sogdiana on the banks of the Charyn River in the territory of the Charyn National Nature Park, to identify and analyse the main factors that can improve the rates of natural regeneration of riparian forest in Kazakhstan in the future. The theoretical basis of the study lies in the analysis of scientific works and highly specialised materials by Kazakh and foreign authors in the field of forestry, ecology and nature conservation on the subject of this study. The methodological approach to fulfilling the tasks set was based on general scientific Methods, in particular observation, measurement, evaluation, a systematic comparative analysis of the material obtained, as well as computational mathematical methods. Qualitative representative material of the expanded field experiment enabled to calculate the level of natural regeneration of fraxinus sogdiana on the control plots of the study area. In addition to the practical field work, an in-depth analysis of worldwide scientific publications on the topic under study was conducted to formulate possible solutions to the problem.

Keywords: fraxinus Sogdiana; natural forest regeneration; riparian forests of Kazakhstan; forest management activities

1. Introduction

In the modern world, particular relevance is given to anthropogenic loads on the biosphere changing the global ecological situation. Erosion processes, droughts, dry winds and desertification have intensified over large areas, the water regime has deteriorated, and the productivity of agriculture has decreased. The global significance of the forest multiplies the responsibility for its conservation and regeneration, especially as it is the ecological framework for the entire planet, a tremendous resource for the economy, for economic growth, for improving the well-being and health of citizens[1)]. The forests of Kazakhstan, and in particular the ash riparian forests of the Charyn National Nature Park, as part of the unique natural complexes of Almaty region, have special ecological, historical, scientific, aesthetic and recreational value. Diseases of various origins cause significant damage to individual trees as well as to entire plantations. They cause the weakening and desiccation of woody plants of different ages, a reduction in the yield of standard planting material, a decrease in the quantity and quality of commercial timber, a partial or complete loss of ornamental plants in cities and settlements, and a loss of the protective functions of trees and shrubs[2)]. Thus, for ash trees in Russia and the USA, a significant damaging factor is ash borers[3-5)]. Furthermore, both natural and anthropogenic factors have a significant impact on the state of current stands of trees and their breeding capacity.

The first category is appropriate to include factors such as climatic conditions in particular regions, periods of droughts and floods, forest fires and other aspects. The second category involves excessive logging, vandalism,

pollution of natural areas by private recreational and industrial facilities, as well as the deployment of construction projects and the siting of transport and other communications[6]. It is particularly worth mentioning the sectoral legislative and legal aspects that are designed to protect important natural objects (forest and land codes), as well as to record regulations and plans for the conservation and development of protected objects. Thus, in the strategy "Kazakhstan 2050" the conservation of forest biodiversity is recognised as a priority of the national strategy and the Action Plan for the Conservation and Sustainable Use of Biological Diversity[].

Kazakhstan's National Biodiversity Strategy and Action Plan prioritizes forest biodiversity conservation, focusing on several key areas. These include:

- Forest protection and management - increasing the area of protected forests in Kazakhstan, improving forest management practices, and reducing the impact of human activities on forest ecosystems.
- Biodiversity monitoring and research - recognizes the importance of scientific research and monitoring to better understand forest ecosystems and their biodiversity.
- Sustainable forest management - promotes responsible forestry practices such as selective logging and reforestation, as well as the development of alternative livelihoods for forest-dependent communities.
- International cooperation - Kazakhstan is a party to several international agreements and conventions related to biodiversity conservation, such as the Convention on Biological Diversity and the UN Framework Convention on Climate Change, and the country works closely with international organizations to implement these agreements[7].

One effective measure of biodiversity conservation is the establishment of specially protected natural areas. One of the priorities for the development of the forest sector is reforestation, which predetermines the stimulation of environmental regeneration work in the area. It is oriented towards the use of natural and artificial methods of reforestation[8]. In China, for example, natural forest conservation programmes (NFCP) have been running since the beginning of the 21st century. The results show that forest cover has increased significantly over about 1.6% of China's territory. Although China's forest conservation policy can have a positive impact on China's forests, it can have some negative impacts on other forest areas around the world. At the same time, although China's environmental policy prohibits the clearing of natural forests, China has become one of the world's leading importers of timber. In the case where associated loss of forest cover elsewhere occurs in areas of high biodiversity, the expansion of forests in China could also result in a significant loss of biodiversity globally[9]. These considerations provide a basis for reflection for current territorial strategies to mitigate global climate change and conserve biodiversity. To address these problems, a systematic approach is urgently needed that simultaneously addresses trade-offs and synergies between conservation, production and consumption in both importing and exporting countries[10]. The relevance of the study is justified, in part, by the fact that conservation and restoration is important for the ash tree, as the species that is the subject of this study, for many reasons. These trees do an excellent job of filtering air in urban plantations, are quite unpretentious about growing conditions and climate, and have a huge practical applicability – producing furniture, household items and hobbies, in scientific medicine is in the research phase[11]. Moreover, the fraxinus sogdiana trees in the Charyn Ash Dacha are relict and specially protected.

The unique contribution of the study lies in the integrated approach that combines practical field work with an in-depth analysis of the world's scientific publications on the subject. This approach allows us to calculate the level of natural regeneration of fraxinus sogdiana based on qualitative representative material from an extended field experiment. This study provides valuable insight into the natural regeneration of fraxinus sogdiana in ash riparian forests of Kazakhstan. The results will contribute to the development of effective strategies and solutions for the conservation and restoration of these important ecosystems not only within Almaty oblast, but also throughout the country. Purpose of the study: to investigate the regularities and features of natural regeneration of fraxinus sogdiana on the banks of the Charyn River in the territory of the Charyn State National Nature Park, to reveal and analyse the main factors contributing to the better natural regeneration.

2. Materials and Methods

The theoretical basis lies in the analysis of scientific works and highly specialised materials by Kazakh and foreign authors in the field of forestry, ecology and nature conservation on the object of this study. The methodological approach to fulfilling the tasks set was based on general scientific methods, in particular observation, measurement, evaluation, a systematic comparative analysis of the material obtained, and statistical methods. Qualitative representative material of the extended field experiment made it possible to calculate the level of natural regeneration of fraxinus sogdiana on the control sites of the study area. The Charyn State National Nature Park was the experimental base for the research. The Charyn ash forest estate, declared a monument of nature by the Decree of the Council of Ministers of the Kazakh SSR No.447-p of March 19, 1964[12], is located within the park. This species of ash has survived only here, in the lower reaches of the Charyn river in the canyon of its tributary Temirlik, so it is more than important to study the conservation of the species in this area.

Figure 1. Location of the Charyn National Park on the map

The fraxinus sogdiana (moisture-loving), Charynsky ash is protected as a relic of the Paleogene epoch. This is where the natural plantations of the fraxinus sogdiana are preserved in their pristine state. They are the most important forest type, with phytocenoses covering about 35% of the forested area. The grove covers an area of 5.014 hectares, of which 1.100 hectares are pure ash. The grove extends for 20 kilometres along the river.

Figure 2. Image of the Sogdian Ash

The study assessed the natural factors influencing natural regeneration of the forest, the economic measures promoting natural regeneration, and other expected and actual aspects affecting the subject of the work in the areas under study. The success of this stage was based on an in-depth analysis of a variety of literary sources and scientific publications, taking into account specific aspects of the region under study, but not excluding the findings of authors from other regions.

Initial assessment data was obtained by visual estimation of the study area. The following instruments were used to measure the taxonomic parameters of the forest: Blume Leiss and Suunto altimeters, Bitterlich and Anuchinprisms forest fullness meters, as well as a tree age gauge. To calculate the seed yield of the control plots, a six-point scale by O.G. Kapper was used[13]. Calculation plots of 2x2m (4m2) were made on a total area of 1ha, where mass counts of naturally regenerated shoots and counts of shoots by age group were made. During the study, the authors divided the grove into three parts: lower, middle and upper in order to assess the natural regeneration of fraxinus sogdiana trees at different levels. The following work was carried out when describing the forest: taxonomic characteristics of the stands (composition, type, age, average height and diameter, fullness, foliage, quality, sanitary condition). Furthermore, a description of the naturally regenerated shoots, i.e. their age, height, density, spread and viability in the grove, was performed. The objectives of this stage are to study the features and patterns of natural regeneration of the fraxinus sogdiana in different forest areas and to determine the frequency of seed reproduction.

The data obtained were subsequently assessed in accordance with the Forest Code of the Republic of Kazakhstan and the 2015 regulations on protection, conservation, use of the forest fund, forest reproduction and forest planting in the areas of the state forest fund. On the basis of the literature review with the analysis of works by foreign authors, and as a result of the study on natural regeneration of Sogdian ash (Fraxinus sogdiana Bunge) in the floodplain of the river Sharyn, Almaty region, the conclusions and practical recommendations were formed.

3. Results

Climatic and soil conditions in Kazakhstan are unfavourable for the growth of trees and shrubs over most of its territory[14]. This is the reason for the formation of forests in the country, especially in the desert, in the form of narrow intermittent strips along rivers. For the country with limited forest resources, it is important to preserve the existing forests in the arid regions of Kazakhstan. Riparian afforestation in the arid and dry southern and south-eastern regions of the country and the conservation, improvement and regeneration of all riparian forests is a very important issue in the forestry sector, with riparian forests being poorly studied.

Given the great importance and diversity of riverine forests in the country's forestry sector, special attention should be paid to studying their characteristics in order to improve the productivity, the composition and longevity of these trees. The republic's riparian forests naturally serve as protective water belts that protect, regulate and store water[15]. Undoubtedly, they have an impact on the climatic conditions of the areas where they are located, improving the microclimate, increasing the humidity and reducing the strength of dry hot winds. It also reduces water evaporation and contributes to the conservation and purity of the river's water resources. Compared to mountain forests, riparian forests have a significant impact on the local microclimate[16].

The main reason for the loss of riparian forests is the reduction of rivers and lakes. A reduction in the amount of river water, in turn, affects groundwater and disrupts the balance. Excessive use of water resources for cultivation

of crops, human needs (hydropower, daily use). Anthropogenic factors disrupt the centuries-old natural balance of forests. At the same time, the volume of riparian forests is decreasing as a result of human activities such as the mass cutting of trees and shrubs for firewood, fires, mass ploughing and irregular cultivation of agricultural lands along riverbanks, cattle grazing and haymaking. The cutting of riparian forests continues. Therefore, an issue of conservation and restoration of riparian forests in all river valleys is currently being addressed. In general, the species composition of riparian forests in Kazakhstan is very small and poor. It should be noted that the composition of riparian forests consists mainly of representatives of the families Salicaceae and Eleagnaceae[16].

The nature of Kazakhstan is attractive because of its uniqueness and diversity of landscapes. Every corner has its own characteristics. As for the Almaty region, it covers all natural zones of the country, from sandy flat deserts to high mountain peaks and permafrost. There are specially formed and preserved relict trees among the varied landscapes[17]. There are species of trees that grew naturally in this area before the Ice Age, and have survived ever since, and one can only imagine them. This tree species grows only under natural conditions on the banks of the Charyn River – Fraxinus sogdiana bunge, a Sogdian ash tree. There are many names for this species of ash (Sogdian, water-loving, river ash, Charyn, Syr Darya, Turkestan). In the wild, the Sogdian ash is found only along the Charyn River in the Almaty region of the Republic of Kazakhstan, i.e. in the lower reaches of the river below the canyons.

At the area where the fraxinus sogdiana is located, the canyons narrow and move away from the river. In other parts of the country, the species does not grow at all. This species of chagan grows from the headwaters of the mountainous Temirlik River, which flows into the Charyn River and originates from the Ketpen Ranges, to the sand dunes at the confluence of the Charyn and Ili Rivers. This is a distance of about 40 km. Due to its moisture-loving nature, this tree species cannot grow on the sandy soils of arid regions. Sogdian ash trees along the Ili River are not found at all. This species does not grow in the canyons of the upper Charyn River. Fraxinus sogdiana, which grows in the river valleys of the Karatau ranges, is not the first high-altitude stratum of this species. This species of ash is not found in other parts of the world. Fraxinus sogdiana is on the verge of extinction[18]. The geographical distance from the nearest chagan type to the Karatau Ranges is 750 km.

The Sogdian ash forest on the Charyn River is a geographically isolated species. In terms of its geographical landscape, the canyon is located in a deep hollow in the desert-steppe zone, where the plants growing here form an isolated population. Due to the influence of the Charyn River, the humidity in the forest increases and there are no severe frosts here[19]. Although Sogdian ash forests have been planted on Terrace-2 since 1939, the area under cultivation is less than 30%. This is due to the fact that these seedlings will dry out quickly if they do not receive regular moistening. As its name suggests, this tree cannot survive without water. Other species of ash cannot compare to the fraxinus sogdiana in terms of moisture-loving properties. In the steppe zone of southern Ukraine and Russia, the Pennsylvanian ash is much more widely planted than the common ash, let alone the Sogdian ash, as it is more drought-resistant. It is very popular because of its good form and resistance to disease (including industrial gassing)[20].

Currently, no afforestation of fraxinus sogdiana trees is taking place in the Charyn State National Nature Park. Conceptually, all the forest protection strips created are in a neglected state, no maintenance work is carried out, and this is one of the main activities for growing sustainable, long-lasting plantations[21]. Other necessary forestry measures are also not implemented, which has an immediate impact on the condition of the plantations. If these plantations are allowed to die today, it will cost more to restore them than to maintain them. For the Charyn grove, the lack of land improvement works is due to the fact that since the construction of the Moynak Hydroelectric Power Station (HPS), there has been a shortage of irrigation water due to a decrease in water volume. At the same time, canals built during the Soviet era are now covered with earth and stones and are unusable.

If the republic's authorities do not pay attention to the restoration of these canals and ditches, the national park administration alone will not be able to cope with it, either financially or physically. Therefore, the study of natural regeneration of fraxinus sogdiana is considered an essential way of conserving riparian forests and is of high practical significance. Tugai is considered an "oasis" located in the arid-desert zone of the republic, and its preservation is an urgent task not only for the national park staff, but also for foresters throughout the country[16]. Although ash seeds ripen in August-September, they are unevenly distributed. In some years, the seed material is stored on the tree for a year and then flies off into the lowlands the following year due to strong winds. Spring melted snow and river water are stored in the lowlands for several days to weeks. After the water has dried up, well-restored shoots of fraxinus sogdiana grow in the lowlands. Such trees usually have a high growth rate[22]. Fraxinus sogdian is also resistant to soil salinity, e.g. it can grow in soils with sulphate and chloride salts.

Based on the methods described in the "main research stage" section of the Materials and Methods chapter, the practical part of the study was carried out. After counting the number of seedlings and young shoots in each calculation area, these were added up, the mathematical average for the age groups was determined and recalculated to 1.0 ha. The calculation of 1 ha of natural regeneration in the reference area is made using the

following formula:

$$N = \frac{n \times 10000}{P}, \qquad (1)$$

where N is the number of seedlings and young shoots per 1 ha; n is the number of seedlings and young shoots on all survey plots; the area of all survey plots is P2 m^2. Thus, according to the "Regulations for the taxation of forests in Kazakhstan" the state of natural regeneration in forests with a reference area is determined by the calculation method. The result of the calculation is shown in Table 1:

Table 1. Assessment scale for natural regeneration of fraxinus sogdian on the Charyn forest estate (number of reliable seedlings) thousand pcs / ha

Assessment of natural regeneration	**Age groups of undergrowth (years)**			**Total number of young shoots aged 11-15 years**
	2-5	6-10	11-15	
Good	3,0 or more	2,0 or more	1.0 or more	3.0 or more
Satisfactory	1.5-3.0	1.0-2.0	0.5-1.0	1.5-3.0
Bad	1.5 or more	1.0 or more	0.5 or more	1.5 or more

To determine the total number of young shoots, the following correction factor was used:

a) for the age group of 2-5 years – 0.3;

b) for the age group of 6-10 years – 0.5;

c) for the age group of 11-15 years – 1.0.

According to the seed and seedling evaluation methodology of V. Kapper, evaluation of fruiting is carried out on a temporary reference plot of 0.1-0.5 ha (the number of trees on the reference plot does not exceed 100)[13]. According to the results of the 2020 assessment, when visually inspecting seed yield along the Charyn River, the level corresponded to a six-point scale of O.G. Kapper, the seeds were very poor and sparse, with some trees giving seedlings in the open air. This leads to the presumption that natural regeneration will be low next year due to the small number of seeds this year. And last year, 2019, the seed level was high, corresponding to a score of 4 on the Kapper scale. Thanks to this, natural regeneration yielded good results in 2021. But the main factor affecting natural regeneration is changes in water levels in the Charyn River. Water levels in the Charyn River have been low this year due to the drought. The peculiarities of forest growth and development in the forests on the Charyn River bank have been reflected in the studies of many scholars[13,16,19,22]. Many of them noted that the condition of the forests and the nature of their changes were clearly influenced by the hydrological regime of the Charyn River. Due to the construction of the Moynak hydroelectric power station, the growth and development of trees and shrubs in the forest will undergo numerous changes. Changes in water supply play a key role in the natural regeneration of the fraxinus sogdian tree.

Table 2. Assessment of natural regeneration of fraxinus sogdian on the bank of the Charyn River (number of germinating seedlings) at the rate of 1 thousand. Pcs. Per 1 ha.

No. of the monitoring plot	**No. of the plot being assessed**	**Plot area, m2**	**Number of germinating shoots depending on tree age**			**Total number in the study area, thousand pcs.**	**Total number of young shoots aged 11-15 years, thousand pcs.**
			2-5 years	6-10 years	11-15 years		
1	5	4.0	3.02	2.05	1.02	6.09	3.04
2	23	3.0	2.04	1.45	0.72	4.21	2.11
3	43	5.2	1.31	0.71	0.43	2.45	1.22
4	6	4.3	3.05	2.11	1.04	6.2	3.10
5	24	4.0	2.10	1.56	0.81	4.47	2.23
6	46	3.0	1.42	0.78	0.48	2.68	1.34

In the course of the study, the authors divided the grove into three parts: the lower part of the grove, the middle part and the upper one. To read Table 2, it should be noted that in the lower part of the grove there were monitoring plots No. 1 and No. 4 where natural regeneration showed good results. From the calculated data in the Table, one can see that there are 3.040 seedlings per ha of naturally regenerated viable seedlings in control plot No. 1 and 3.100 seedlings in control plot No. 4, respectively. The middle part of the grove has worse indicators than those for the lower part. In this case the data obtained is that there are 2.110 seedlings per ha of naturally regenerated viable seedlings in control plot No. 2 and 2.230 seedlings in control plot No. 5, respectively. In the upper part of the grove, natural regeneration rates are very low and here, there are only 1.220 seedlings per ha in control plot No. 3 and 1.340 seedlings per ha in control plot No. 6, respectively. The results of the field studies were compared with the data from the Sogdian ash tree natural regeneration assessment scale. The comparative analysis reveals that the natural regeneration of monitoring sites No. 1 and No. 4 can be assessed as "good", while the natural regeneration of monitoring sites No. 2 and No. 5 can be assessed as "satisfactory" and the natural regeneration of monitoring sites No. 3 and No. 6 – as "poor".

The study and implementation of silvicultural measures to promote the natural restoration of Sogdian ash in the floodplain of the Sharyn River face several difficulties and limitations. The natural regeneration and growth of Sogdian ash trees depend on water levels in the Charyn River. If water levels are low and the weather is dry, young shoots from newly germinated seeds could be affected by drought. Therefore, the availability of sufficient water is crucial for the successful implementation of silvicultural measures.

Climate change can have significant impacts on forest

ecosystems, including the natural regeneration of tree species. Changes in temperature, precipitation patterns, and extreme weather events can affect the viability of Sogdian ash seeds and the survival of young seedlings. Adapting silvicultural measures to the changing climate conditions is necessary for long-term success. Sogdian ash trees are susceptible to various pests and diseases, which can cause rapid and widespread damage to the forest stands. Efforts must be made to prevent and control the spread of these pests and diseases through proper forest management practices and disease-resistant tree varieties.

While progress has been made in the field of science and technology, agro-ecological research specific to Central Asia, including the study of Sogdian ash restoration, still faces challenges. Overcoming the crisis in agro-ecological research and applying advanced scientific methods are crucial for the successful implementation of silvicultural measures and achieving sustainable development goals.

4. Discussion

The main threats to the natural regeneration of ash trees and the preservation of current tree stands include the reduction and degradation of forest ecosystem diversity, increasing economic market activity, drought and desertification, together with increasing risks of forest fires. For partially or totally endangered trees in Kazakhstan, the status of existing genetic reserves is clarified annually and measures are taken to maintain the conservation regime in these areas[18]. All in situ conservation objects are under state control. The direct protection of species is carried out by government agencies. To reduce the destruction risks of fraxinus sogdian, continuous monitoring of its condition is necessary.

The research data described in the book "High altitude flora and vegetation of Kazakhstan and the effects of climate change"[23] indicate that the vegetation of mountain systems has undergone reconstruction. The decrease in the values of SAVI (soil-adjusted vegetation index) is probably due to the aridisation of ecosystems, leading to a decrease in the number of some species, a decrease in the percentage ratio of vegetation cover to biomass. Rare, endemic and endangered plants, as well as plants and biocenoses with a small range appear to be particularly vulnerable to the adverse effects of climate change against a background of general xerophytisation of the vegetation cover. Analysing these results and conclusions in relation to the subject of the study, the authors reaffirm the imperative need to maintain water balance (irrigation systems and canals) to preserve the relic grove of Sogdian ash trees in the Charyn River valley.

Today, the republic uses traditional methods of plant propagation – seed and vegetative propagation. However, these methods have very serious drawbacks. For most species, and above all for tree species, the problem of reproduction, despite intensive scientific research in this area, remains to be solved[24]. Limited reliance on seed reproduction and excessive use of vegetative propagation methods may hinder conservation efforts and jeopardize the long-term survival of rare and endangered plants.Kazakhstan has a diverse range of ecosystems, and genetic diversity is crucial for plants to adapt to various environmental conditions. The lack of genetic diversity resulting from seed and vegetative reproduction can make plant populations in Kazakhstan more susceptible to diseases, pests, and changing climatic conditions. Seed and vegetative reproduction methods, which may limit genetic variation and adaptability, can hinder plants' ability to cope with specific local conditions. This could affect the productivity, resilience, and survival of agricultural crops and native plant species in Kazakhstan. Limited reliance on seed reproduction and excessive use of vegetative propagation methods may hinder conservation efforts and jeopardize the long-term survival of rare and endangered plants[24].

The development and introduction into the forestry of the Republic of Kazakhstan of fundamentally new methods and techniques of propagating deciduous and coniferous tree species, shrubs and flowers, based on modern methods of agricultural biotechnology, is of great importance in the successful solution of these directions. The measures to provide forest cultivation works with planting material with improved hereditary qualities and continuation of works on formation of a permanent forest seed base are carried out by the Republican State Enterprise "Republican Forest Selection Centre"[25]. Genetic and biotechnological enhancement of species is a scientific breakthrough that has made it possible to preserve endangered species and improve their viability and quality characteristics. Genome-wide detection of candidate genes for functional traits within a species usually involves sequencing large samples of phenotyped individuals or linkage analysis across several generations. Sometimes a more effective approach may be to identify genes by detecting amino acid residues shared by species possessing the trait. For common ash and Pennsylvanian ash trees, similar studies are carried out in order to increase resistance to ash borer[26].

Facilitating collaboration between researchers, local communities and policy makers is critical to the success of forest management interventions to promote natural regeneration of the Sogdian ash tree in the Sharyn River floodplain. Creating platforms or forums where researchers, local communities, and policy makers can come together to share knowledge, experiences, and discuss strategies for restoring the Sogdian Ash Borer. This can be done through workshops, conferences or regular meetings specifically dedicated to the topic.

Involve local communities in the decision-making process and ensure their active participation in the restoration work. Their traditional knowledge and experience can make a significant contribution to the

success of forest management activities. Ensuring that research findings and recommendations are incorporated into policy and decision-making processes. Collaborating with policy makers to develop and implement policies that support the conservation and restoration of Sogdian ash forests.

For the purposes of the study, it is also worth highlighting the prospects of working on the artificial breeding of fraxinus sogdian trees with greater drought tolerance. Furthermore, obtaining more viable seedlings in large numbers will enable them to be planted in the territory of the Charyn Nature Reserve and possibly in other areas. The emerald ash borer, Agrilus planipennis, native to East Asia, is an invasive pest of ash trees in North America and European Russia. This quarantine species poses a threat to ash trees across Europe. A survey in ten regions of European Russia in 2019-2020 showed that the emerald ash borer has spread faster and further than previously thought. New infested areas were found for the first time in St Petersburg (110-120 km from the EU border: Estonia, Finland) and in the Astrakhan region (50 km from the border with Kazakhstan). It is possible that new enclaves may appear in cities in Eastern Europe and Kazakhstan, far from the current known range.

All previously known infestations in the European part of Russia occurred on green ash (Fraxinus pennsylvanica), which was introduced from North America, and individual trees of European ash (*F. excelsior*)[27]. But it is possible that, over time, this parasite species will also invade local species as new areas are developed and food becomes scarce. The borer has a significant impact on the condition of current tree stands, and weakened trees produce poor quality seeds, which will negatively affect the level of natural regeneration. To address the problem of biological protection of ash trees against borers, three species of parasitic insects have been studied and started to be produced in the USA[28]. Moreover, ash tree mortality caused by Hymenoscyphus fraxineus is currently an acute problem in Europe[29]. Among the possible routes of invasion of the fungus into Europe from its natural range in easternmost Asia, movement along the inextricable Eurasian ash species habitat chain cannot be ignored. In Estonia, a species of ash tree, Fraxinus sogdiana, naturally growing in Central Asia, was found to be susceptible to H. Fraxineus[30-33]. Thus, for Sogdian ash trees, the development of prevention and protection methods against species-specific entomoparasites and fungi is also relevant.

Continuing to talk about the possibilities of genetics, interspecific hybridisation can take advantage of heterosis and most widely combine dual parental traits and is an effective strategy for improving species and stress-resistant cross-pollinated tree selection[34-36]. Species of Fraxinus L. are important for landscaping, sawn timber and woody plantations. For instance, China has solved the problems of poor cold adaptation associated with the introduction of Fraxinus sogdiana to Maoershan (Heilongjiang Province, north-eastern China), improved the pest resistance of Fraxinus mandshurica, and also took advantage of the characteristics of F. mandshurica and F. sogdiana by performing their interspecific hybridisation[37,38].

Fraxinus sogdiana, a species of ash tree, is critically endangered due to its significant ecological value in water and soil protection. Natural regeneration has shown positive results in 2020, but young shoots from 1-2 year old seeds could be affected by drought in 2021 if water levels in the Charyn River are low. River water levels directly impact the natural regeneration and growth of fraxinus sogdian seeds, which in turn affect groundwater and forest development. To preserve fraxinus sogdiana, irrigation systems and ditches can be constructed in areas where they are forming. Other tree species can be introduced to provide shade and support the growth of young fraxinus sogdiana shoots. Increasing the floodplain during spring floods and considering factors such as groundwater levels, soil salinity, climate change, and river flow regulation are crucial for successful natural regeneration.

Studies show that fraxinus sogdiana mainly regenerates in the middle and lower parts of the spring floodplain and in forested areas away from rivers. Changes in water levels caused by the construction of hydroelectric power stations have disrupted the natural balance and composition of flora and fauna. Regular sanitization of tree stands is necessary, and cooperation with organizations involved in forest conservation and genetic resource management can positively impact ash forest stands. Disease prevention and forest breeding are vital for increasing tree growth, protective impact, and overall forest quality. Advancements in science and technology are essential for overcoming the crisis in agro-ecological research and achieving sustainable development in Central Asia.

5. Conclusions

Fraxinus sogdiana is on the verge of extinction, with its enormous water and soil protection value. In 2020, natural regeneration has shown good results as the seed crop of Sogdian ash trees has a high performance in 2019. However, naturally regenerated young shoots from 1-2 year old seeds could be affected by drought during 2021 if water levels in the Charyn River are low and the weather is dry. River water level is a factor directly affecting the natural regeneration and growth of fraxinus sogdian seeds. River water, in turn, has a direct impact on groundwater and has a significant impact on forest growth and development.

In conclusion, in order to preserve fraxinus sogdian in the forests along the Charyn River, it can be introduced in the areas where they are beginning to form, through the construction of irrigation systems and ditches. Seeds of other tree species germinate well between planted woodland and shrubs (poplar, spruce) or seeds that have been sprinkled during irrigation and during spring floods.

These woody species shade the seedlings and young shoots of the Sogdian ash and enable them to grow well. A number of measures also need to be taken to artificially increase the floodplain during the spring floods. It should be noted that natural regeneration of Sogdian ash trees is closely linked to fluctuations in groundwater levels, soil salinity and salinity processes, climate change and river flow regulation.

Studies demonstrate that the growth dynamics of tree and shrub species vary downstream. Fraxinus sogdiana is mainly naturally regenerating in the middle and lower parts of the spring floodplain, as well as in ravines and lowerings of the forest canopy, forming a pure one-year old Sogdiana ash tree. Fraxinus sogdiana can be found in forests, in low-forested areas away from low-lying rivers. During the construction of the Moynak hydroelectric power station in the upper Charyn River, water levels often fluctuated, which in turn led to changes in groundwater conditions in the region. These factors have led to the floristic and faunal composition and their location in the forest, the migration of animals and birds and the disturbance of the natural balance over the millennia, including the formation of the main resource in the Sogdian ash forest.

According to field studies, a large number of Sogdian ash trees and their branches were recorded in the grove, which had dried out, been broken by the wind or uprooted. The tree stands therefore urgently need to be sanitised every year. One of the possible human activities, which in the future could have a significant positive impact on ash forest stands, their renewal and graduation from the status of "threatened with extinction" is cooperation with organisations involved in the conservation and rational use of forest genetic resources. Given the high quality of ash wood, its excellent physical properties and its wide range of human uses in industry, it is important to secure and control all plantations at the survey sites in order to reduce the risks of vandalism and illegal logging.

Species-specific parasitic insects and fungi can cause rapid and irreparable damage to a large number of trees at the same time, so it is essential to put as much effort as possible into disease prevention. Thus, forest breeding is one of the main factors in solving the main task of forestry - increasing the speed of growth, protective and environmental impact, yield of trees and plantations, biological stability of forest species and plantations (frost and drought resistance, entomo- and phytotolerance, etc.), the implementation of introduction and expanding the range of valuable and zoned species and improving the quality of forests in the Republic of Kazakhstan, which belongs to the low forest cover countries. And microcloning formulas make it possible to achieve a thousandfold increase in planting material per year.

Considerable progress has been made in science and technology in the last ten years, but agro-ecological research and science in this field in Central Asia is still in crisis. Overcoming this crisis and applying advanced methods in science and technology are key issues for future development. Science and technology can provide a general shift in knowledge when it comes to recognising processes and initiating sustainable development. For future research to better understand and support the natural regeneration of Sogdian ash and other similar species in the region, the authors can suggest the following directions:

Ecological studies: Conduct comprehensive ecological studies to investigate factors affecting the natural regeneration and growth of the Sogdian ash tree, including the effects of river water levels, groundwater fluctuations, soil salinity, climate change and regulation of river flow. Seed germination and propagation: This research should focus on understanding the wilting and germination requirements of Sogdian ash seeds and developing effective propagation methods to produce healthy seedlings for restoration efforts.

Hydrological management: Explore water management strategies, such as building irrigation systems and ditches, to ensure sufficient water for the growth and development of the Sogdian Ash along the Charyn River. Forest Health and Disease Prevention: Investigate the impact of species parasitic insects and fungi on the ash forest ecosystem and explore methods for early detection, monitoring and management of these pests to minimize damage to Sogdian ash trees.

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