Issues of ecosystem conservation and safety (using the example of the "Semey Ormany" of the Republic of Kazakhstan)

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Abstract. The article analyzes the issues of preserving the integrity of the planet's ecosystem in a rapidly changing world and climate change on the Earth. The authors note that at the present stage, threats arise in nature that require coordinated actions to restore, ensure the conservation and rational use of natural resources, including unique natural complexes. Among these is the ribbon-like pine forest, the history of which is described in the article. The object of the study is a forest natural reserve located in the east of the Republic of Kazakhstan – the "Semey Ormany". The authors research environmental conservation activity, forest protection and reforestation activities of the "Semey Ormany", i.e. activities to protect ecosystems necessary to preserve our environment and ensure sustainability for future generations. The analysis carried out in the article allows us to gain and recommendations were made for the conservation of biological diversity.

1 Introduction

In the context of the globalization of the world economy and climate change on the planet, natural ecosystems face unique challenges that have not been encountered before [1-2]. The protection of ecosystems is becoming one of the main tasks of our era [3-4]. Every day we lose our unique biodiversity and valuable natural resources, which endangers not only the ecology, but also the vitality of the planet as a whole [5-6].

Terrestrial ecosystems are territories with different landscapes, which account for about 30% of the Earth's surface, including forests, grassy areas and deserts, ecosystems are a source of jobs, livelihood, food, fuel and medicines for us. More than 1.6 billion people in the world are directly dependent on forests, including more than 10 million people officially working in the forestry industry and many people working in forestry informally. From 65 to 80% of the world's population depends on medicines used as first aid products,

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the source of which is forests [7]. Any disruption to this delicate balance risks triggering irreparable global catastrophes.

2 Materials and methods

The research methodology is based on the interrelation of methods of various sciences in solving tasks, a systematic approach to finding solutions and determining their consequences. System analysis involves studying the ecosystem as an integrated system, including the relationships between its components, helps to understand complex environmental processes and predict the consequences of changes in the ecosystem. The interdisciplinary approach is an interconnected system of integration of knowledge in the field of natural, social and technical sciences and allows solving the problems under study from a comprehensive perspective.

Historical methods allow us to trace what changes have occurred in the ecosystem in the past and how this affects modern conditions.

All these methods together are important tools for studying ecological systems, their functioning and environmental impact, as well as for developing measures to improve the management and conservation of biodiversity.

3 Discussion of the results

Scientists all over the world are concerned about the conservation and safety of ecosystems. Attempts to solve the problem under study were made by foreign scientists. In particular, issues of natural forest restoration after fires were raised, the importance of proper ecosystem management, taking measures to eliminate the consequences of ecosystem disturbances and the need for their restoration, the role of responsible organizations in mitigating the effects of forest fires, protecting wildlife habitats were pointed out [8-9].

The topic of a separate study was also the trends, types and global spread of fires in different regions of the world, which also had a certain impact on ecosystems. Scientists analyzed the consequences of forest fires, in particular, the interrelation between fires and changes in vegetative cover, the expansion of agriculture and loss of forests, the transformation of forests into arable land and the reverse process [10].

Ecosystem restoration, researchers believe, can potentially lead to mitigation of the effects of climate change, restoration measures can also contribute to climate change adaptation and sustainability, sustainable use and conservation of biodiversity, food and water security and economic prosperity, in this connection global initiatives have been undertaken to restore degraded and deforested lands around the world [11].

Kazakhstani scientists conducted field studies of the process of restoring pine forests after fires [12]. The problems of legal provision of environmental safety were studied. In particular, the analysis of the national legislation of Kazakhstan, international conventions (agreements) in the field of environmental safety, ratified by the Republic of Kazakhstan was carried out [13].

The unique ecosystems include ribbon forests, which are mainly, pine plantations stretching along riverbeds in parallel strips from 5 to 40 km wide. Their uniqueness is also in the fact that they grow on sandy ancient sediments, which creates a special microclimate and a unique habitat for rare endemic species. The ribbon forests of the Irtysh region consist of Scots pine (Pinus Silvestris).

It is assumed that in the relatively recent geological past, the melt waters of the Altai glacier, overflowing the barely outlined bed of the Ob River, poured out to the southwest,

into the valley of the Irtysh River, washing a system of parallel hollow on the surface of the Ob-Irtysh interstream area.

As the northern glacier retreated and the Altai ice masses decreased, the discharge of water through the hollows into the Irtysh Valley decreased, and from sand deposits of water-glacial origin, under the influence of wind were formed gradually sand masses of dune character, soon overgrown with pine forest.

On the territory of the Ob-Irtysh interstream area there are five valleys of glacial water runoff. On the border of the Altai Territory and Kazakhstan, two valleys Kasmalinskaya and Burlinskaya flow with the third valley Loktevskaya, forming a vast island of sands, and then in the form of a peculiar delta of the ancient river they reach the Irtysh, where they meet with its terraced sands. Thus, in the Ob-Irtysh interfluve area, narrow parallel ribbons of sandy soils with pine forests appeared among the chernozem and dark chestnut steppes.

3.1 History of creation

The beginning of the economic development of ribbon forests was laid by the Ural industrialist Demidov in 1735. At that time, all the plantings served as energy raw materials for local factories. The exploitation of forests was carried out in a destructive manner: ten thousands of hectares of forest were destroyed.

At the beginning of the 20th century, the main threat to pine forests was fires that spread over huge areas. So in 1900, 430 forest fires were registered in the ribbon forest, with a total area of 190 thousand acres. From the end of the XIX century to the mid-20s of the XX century, the area of the forest decreased by 35% due to fires and unauthorized felling. In the 1920s, the Semipalatinsk branch of Kazlestrest was established to monitor the protection and use of forests. This department, in turn, was reorganized into an industrial farm in 1930, and then, in 1934, into a forestry plant.

The exploitation of forest resources was carried out mainly for the purpose of industrial processing of wood. It was only by the 1940s that there were changes in the prioritization of human understanding. In 1947, due to the increase in public attention and the need to take effective measures to preserve and restore forest plantations damaged by numerous fires and endless unauthorized cutting, several forestry enterprises were organized under the Semipalatinsk Regional Forestry and Forest Protection Department of the Ministry of Agriculture.

Prerequisites for the essential reorganization of forestry in the Republic of Kazakhstan also became a sharp increase in cases of poaching, plundering of forests and deliberate arson of pine forests by “entrepreneurs”, with the aim of subsequent development of slash fire and sale of wood.

In 2003, the Government of the Republic of Kazakhstan decided to create two State forest natural Reserves “Semey Ormany” on the territory of the East Kazakhstan region and “Ertis Ormany" in the Pavlodar region [14].

In 2006, the Law of the Republic of Kazakhstan “On Specially Protected Natural Territories” was adopted [15], which prohibited cutting activities for main use, i.e. raw-growing forests in a state of technical maturity, on the areas of the nature reserve fund, also limiting the secondary use and development of infrastructure on the territory of the state forestry fund.

The uniqueness of the “Semey Ormany” Reserve lies also in the fact that rare plants grow on its territory. Thus, 243 plant species belonging to 57 families and 142 genera have been identified in the eastern territory of the “Semey Ormany” Reserve. 11 plant species are listed in the Red Book of Kazakhstan, which is about 4.5%: Cladonia rangiferina – Cladonia rangifera or deer moss, Stipa pennata – Feather grass, Nymphaea candida – white water lily, Rosa pavlovii – Pavlov's Rosehip, Tulipa biflora – Two-flowered tulip, T.

schrenkii – Schrenk's tulip, Pulsatillapatens – windflower, Adonis vernalis – spring adonis, Paeonia anomala – Urals peony, Valeriana chionophila – Valerian snow-loving, Veronica alatavica – Veronica alatavskaya.

3.2 Environmental protection activities

The "Semey Ormany" Forest Nature Reserve was found to protect the ribbon pine forests that play an environmental role in the East Kazakhstan Irtysh region. Forest ecosystems of this type are vulnerable to fires, pests and diseases of the forest, poaching and wood cutting.

Dry pine forests located in a region with a hot climate, where little precipitation falls during the warm season, dry thunderstorms and severe dry winds are frequent, are highly susceptible to fires. For a significant part of the spring-summer-autumn period, the fire hazard class is defined as the V class of extreme fire danger. Table 1 shows the data, in addition to forest fires from thunderstorms, there are other causes of forest fires.

Table 1. Information on forest fires for the period 2018–2023 [16].

Years	Number of cases	Including					Total area (ha)	Including the one covered with forest	Damage thousand tenge
		From the thunderstorm	Through the fault of other organizations	Through the fault of the population	From grass fire	From an unspecified causes			
2018	99	86	-	2	2	9	254.7	254.1	86267.9
2019	130	106	1	6	5	12	76.86	14.58	7333.5
2020	171	162	-	7	1	1	3573.01	2148.68	1 814145
2021	147	126	1	-	1	19	35.545	20.585	11534.3
2022	260	222	-	1	5	32	719.919	308.057	14119.8
2023	191	222	-	1	5	32	66738.5	56216.4	162818587.4
During 6 years	998	924	2	17	19	105	71398.5	58962.4	164751988.7

The fire-fighting measures carried out by the "Semey Ormany" Reserve are presented in Table 2.

Table 2. Amount of fire prevention measures in 2018–2023 [16].

No.	Measures	2018	2019	2020	2021	2022	2023
1	Arranging of fire barrier lines, km	53.8	57.3	62.3	43.9	182.3	187.1
2	Two-time maintenance of fire barrier lines, km	13272	13379	13387	13587.2	13443.4	12583.7
3	Cutting of fireproof breaks and compartment lines	259.1 km	60.2 km	19.3 ha			
4	Installation of banners	194	125	230	144	144	144
5	Issuance of regulations to agricultural enterprises, pcs	815	498	534	502	459	483
6	Distribution of leaflets	11691	11330	7317	6520	5705	5740
7	Conducting seminars, lectures and talks	2518	3730	1598	1335	1119	429
8	Media spot Including Television Radio Publication of articles	 5 1 46	 11 44	 9 1 63	 7 1 56	 6 1 47	 6 1 44

An important role in protecting forests from fires is played by constant preventive and explanatory work with the population, media spot, interaction with all interested bodies and individuals in the region of the reserve location. There is an agreement on cooperation between the fire service authorities of the East Kazakhstan region, as well as an agreement on cooperation between the forest management of the Altai Territory of the Russian Federation on timely prevention, detection, extinguishing of forest fires and mutual assistance.

In 2011–2013, a 24-hour early recognition system for forest fires based on the use of German Fire Watch technology was installed on the territory of the "Semey Ormany". The territory is monitored in real-time environment. The system provides an overview of the area with high accuracy using advanced telemetry technology. Fire trucks are equipped with navigators. According to the coordinate data, foresters with the help of a navigator can quickly detect the fire source.

Thanks to innovative technologies and the implementation of a German optical sensor system, which has no analogues in the CIS, any ignition is fixed at the initial stage and does not allow fires to spread.

In addition to extending the scanning surveillance system to the entire territory of Ormany, the reserve provides the following measures:

- Clearing of section lines from wood dirtiness.
- Conducting controlled firing.
- Mowing of grass on the borders of the State Forest Fund.
- Fire prevention propaganda in the media.
- Organization and maintenance of forest fire stations.
- Hiring fire watchtower observers.
- Ground patrol.
- Cleaning of territories around settlements in a strip of 300 meters.
- Routine well maintenance.

3.3 Forest protection measures

The condition of pine forests is greatly influenced by pests and diseases of the forest. Therefore, timely and high-quality implementation of forest protection measures, which include forest pathology examination and chemical control, as necessary, help to preserve the ecosystem of ribbon forests of the Irtysh region.

In fire-damaged, dry-resistant plantations, forest pathology examinations are carried out for subsequent appointment and sanitary and health measures. Forest pathology examination helps to prevent the mass appearance and spread of pests and diseases of the forest, increase forest productivity and create a basis for its further improvement.

Thus, in the foci of shrinking forest stands and in plantations that died from fires, according to the Sanitary Rules of the Republic of Kazakhstan and the Rules of logging in the Forests of the Republic of Kazakhstan, dry trees are cleaned in order to prevent the spread of pests, diseases and for general forest improvement.

To organize timely measures to regulate the number of particularly dangerous pests, an aerosol generator of controlled dispersion (GARDUMO-RD) has been used since 2016, which allows timely processing of plantations against needle-foliage and leaf-eating pests in small areas and to prevent their spread to large areas. The dynamics of the development of foci of forest pests in the territory of the "Semey Ormany" in 2022 is shown in Table 3.

Table 3. Dynamics of the development of foci of coniferous and leaf-eating pests of the forest according to the State Natural Forest Reserve GLPR "Semey Ormany" in 2022 [16].

Name of pests	It has arisen again, ha	Reduction of the areas of foci due to the influence of natural factors (weather conditions, entomophages, epizootics) and terrestrial chemical control measures, ha	Total foci at the end of the reporting period, ha
needle-eating insects – pine web-spinning sawfly (Acantholyda posticalis Mats.)	744	709	35
needle-eating insects – the pine caterpillar (Dendrolimus pini L.)	1347.2		1347.2
Total:	2091.2	709	1382.2

The total area of the foci at the end of 2022 according to the "Semey Ormany" was 1382.2 hectares, of which:

- Pine caterpillar (Dendrolimus pini L.) – 1347.2 ha.
- Pine web-spinning sawfly (Acantholyda posticalis Mats.) – 35 ha (Table 3).

In 2023, the dynamics of the development of foci of forest pests changed in the territory of the "Semey Ormany", as shown in Table 4.

Table 4. Dynamics of the development of foci of coniferous and leaf-eating pests of the forest according to State Natural Forest Reserve "Semey Ormany" in 2023 [16].

Name of pests	The area of foci at the beginning of the year, ha	It has arisen again, ha	Reduction of the areas of foci due to the influence of natural factors (weather conditions, entomophages, epizootics) and terrestrial chemical control measures, ha	Total foci at the end of the reporting period, ha
needle-eating insects – pine web-spinning sawfly (Acantholyda posticalis Mats.)	35	803	796.3	41.7
needle-eating insects – the pine caterpillar (Dendrolimus pini L.)	1347.2		1347.2	0
Total:	1382.2	803	2143.5	41.7

Foci of pests and diseases of the forest at the end of 2023 were 41.7 hectares (Table 4).

Currently, the following forest protection measures are relevant for the "Semey Ormany":

- The current forest pathology examination is carried out by state inspectors of forest protection in order to monitor the forest pathology situation on the territory of the state forest fund in forestry.
- Soil excavations are carried out in order to determine the wintering stock of pests and a detailed examination of plantings to identify insect pests of the forest.
- To attract insectivorous birds, nesting sites are made and hung in plantings.
- In order to preserve the habitats of forest ants, one of the main types of entomophages against harmful organisms, work is in progress to enclose anthills.
- Carrying out measures to regulate the number of pests (chemical control).

The “Semey Ormany” actively conducts reforestation activities on its territory, which include clearing areas of burnt timber, soil preparation, harvesting and processing of forest seeds, planting and caring for forest crops, growing planting material, planting forests, supplementing forest crops, sowing nursery farms and greenhouses, maintenance of the irrigation network, maintenance of cone dryers, maintenance of electrical lines, repair of planting machines.

The successful cultivation of the planting material of scots pine in the forest nurseries of the “Semey Ormany” depends on many factors, including the yield of pine cones. In this regard, the harvesting of cones is carried out with the expectation of obtaining a two-year supply of seeds. The highest yield score of Scots pine is 5 points, which, according to the biological characteristics of the breed, is repeated at intervals of 4–7 years.

There are cone dryers in 7 branches in the forest reserve for processing cones. The productivity of cone dryers ranges from 200 to 450 kg of cones per day. The seed yield is 1%, that is, when processing 1 ton of cones, only 10 kg of seeds are obtained.

The seeds obtained after processing, de-spraying and cleaning are carefully packed by the workers of the cone dryers in pressure-proof glass containers in batches weighing 50 kg and marked with labels indicating the main parameters. To study and determine the quality class of seeds, samples weighing 50 g are taken from each batch and sent to the laboratory of the forest seed station in Semey.

Sowing of seeds in the forest nurseries of the reserve in order to obtain standard planting material for reforestation works is carried out annually in the month of May. For the cultivation of scots pine seedlings, 8 forest nurseries operate in the reserve, the producing area of which is 38 hectares.

In 2016, a complex of a forest nursery and a forest seed station was put into operation, which allows using innovative technology to grow seedlings with a root-balled tree system (RTS), as well as 2-year-old seedlings of scots pine.

The complex of the forest nursery and the forest seed station consists of two sections: a permanent forest nursery with an area of 17.1 hectares and a forest seed and greenhouse complex with an area of 3.3 hectares. The permanent forest nursery specializes in the cultivation of two-year-old seedlings of Scots pine, provides for a 3-month crop rotation according to the early steam system.

The entire process of growing seedlings with RTS is automated and includes drying pine cones in drying cabinets, sorting and drying of the obtained seeds, an integrated line for filling cassettes with substrate and spot sowing cassettes with seeds, transportation and placement of cassettes in greenhouses. Before sowing, the seeds are stratified and treated with fungicides.

The soil germination rate is up to 95% by growing seedlings using innovative technology. For comparison, when seedlings are grown in the traditional way in the open ground with a seeding rate of 60 kg of pine seeds of class 1 quality per 1 hectare, the soil germination rate is 20–25%.

The quality of seedlings with a root-balled tree system is significantly higher than seedlings grown in the traditional way, since the root system is not disturbed or dried up during planting, which increases the survival rate of forest crops.

The average annual productivity of the Complex of a forest nursery and a forest seedling station for growing seedlings of Scots pine with a root-balled tree system is 2866.5 thousand units (Figure 1).

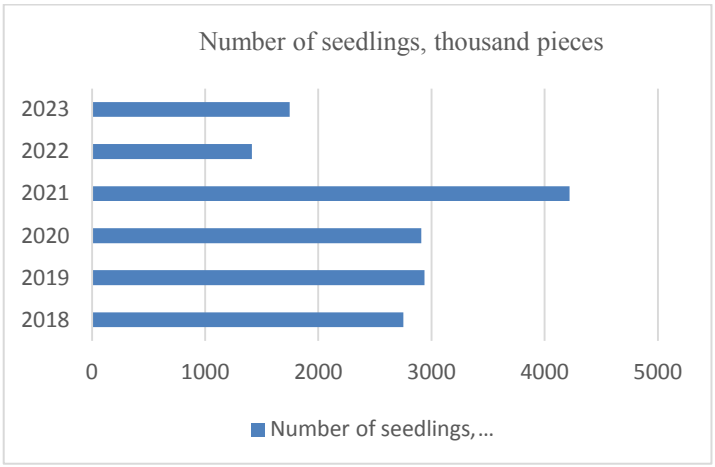

Fig. 1. Information on grown seedlings of Scots pine with a root-balled tree system in 2018–2023 [16].

Annually, branches of "Semey Ormany" plant forest crops on an area of 3600.0–4500.0 hectares, which is reflected in Table 5.

Table 5. Information on planting of forest crops for the period 2018–2023 [16].

Year	Area, ha	including spring seedlings, ha		including autumn seedlings, ha	
		Bare root system	Root-balled tree system	Bare root system	Root-balled tree system
2018	3825.5	3150.5		675.0	
2019	4076.0	3400.0		676.0	
2020	4105.0	3553.0		552.0	
2021	3600.0	3300.0		300.0	
2022	4504.0	3497.0	276.1	336.0	394.9
2023	2440.1	1785.8		654.3	
Total:	22550.6	18686.3	276.1	3193.3	394.9

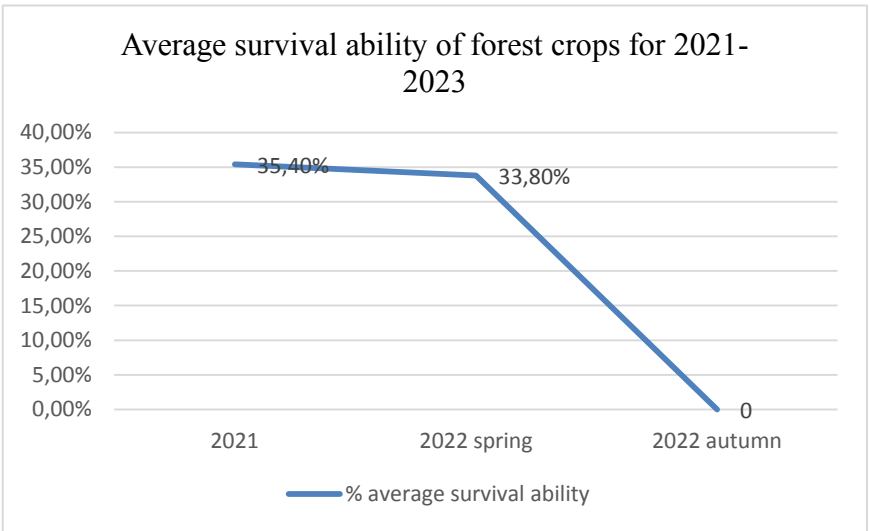

Fig. 2. Average survival ability of forest crops for 2021–2022 [16].

Low survival ability of forest crops in 2022 is associated with adverse weather conditions (lack of precipitation, dry winds and high air temperatures during the growing season).

4 Conclusion

Thus, the basic ecosystem protection measures necessary to preserve the integrity and safety of ecosystems in order to ensure sustainability for future generations should be observed.

The adoption of legislative acts aimed at regulating the use of natural resources plays an important role in preserving vulnerable ecosystems and preventing the illegal use of these resources to maintain a balance in the environment.

Conducting environmental studies makes it possible to assess the state of ecosystems and take the necessary measures for their protection and restoration, which contributes to the conservation of biodiversity and the sustainable use of natural resources.

Public awareness can increase people's awareness of ecosystems and their importance, as well as attract support for initiatives to protect them.

The development and implementation of programs for the restoration of destroyed ecosystems makes it possible to restore the damage caused by human activities and restore balance in natural communities.

The protection of ecosystems is an important issue that requires efforts on the part of government organizations, the public and each individual. The application of these measures will help preserve the richness of nature and ensure sustainable development for future generations.

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