DEVISING RECOMMENDATIONS BASED ON A COMPREHENSIVE ASSESSMENT OF THE SOIL-GEOBOTANICAL CONDITION OF LAND PLOTS FOR EXECUTING AFFORESTATION ACTIVITIES

The land fund is in constant flux. Lands are transferred from one category and land to another. The deterioration of the ecological state of the land, the development of erosion processes, desertification, salinization, pollution by chemical and radioactive substances, forest and shrubland overgrowth of land annually exclude significant areas from use.

This paper reports a study of forestry stations located on the territory of Northern Kazakhstan. The soil was investigated by the method of laying soil sections and semi-pits with a description of the power of the horizons. The structure of the soil was determined by the method of breaking down soil samples. The granulometric composition was determined by the wet method with a division into sand, loam, light loam, medium loam, heavy loam, and clay. The chemical analysis of soil samples was carried out in a certified laboratory. Soluble carbonates are present in the samples from the Burluk forestry station. According to the structure and chemical analysis, the types of soils for each forestry station were defined. Based on the study's results, recommendations were devised for the categories of areas. In addition, the areas of plots suitable for all major forest species and areas with existing forests, forest crops, overgrown with self-sowing were determined.

During the reconnaissance route-loop survey of land plots, the types of plant associations were identified. A comprehensive ecological and geographical study of a forestry station was carried out to execute afforestation operations. Basically, the identification of types of plant associations has made it possible to conduct a preliminary assessment on the ground about the quality of the studied areas for the restoration of forest areas. General recommendations were compiled from the direct conduct of surveys on the ground; however, systematic monitoring, using remote sensing methods of the Earth, could facilitate the ongoing research. Building on the method of integrated ecological and geographical research could in the future significantly improve the efficiency of forest management activities in general and minimize losses associated with environmental influences

Keywords: remote sensing, geobotanical state of land plots, afforestation, integrated assessment

N a z y m   S h o g e l o v a
Corresponding author
Doctoral Student
Department of Geodesy
International Educational Corporation
Ryskulbekova str., 28, Almaty,
Republic of Kazakhstan, 050060
E-mail: nazym-shogelova@mail.ru
S e r g e y   S a r t i n
Candidate of Physical and Mathematical Sciences,
Head of Department
Department of Physics*
T i m u r   Z v e r y a c h e n k o
Candidate of Pharmaceutical Sciences,
Associate Professor
Department of Chemistry*
*North Kazakhstan University named
after Manash Kozybayev
Pushkin str., 86, Petropavlovsk,
Republic of Kazakhstan, 150000

1. Introduction

Forecasting is a necessary and important component of the effective management of any complex economic, social, or natural process or phenomenon. Geographical forecasting in environmental management became widespread in the 1960s.

Rational nature management implies the optimal solution to environmental problems facing the territory, which arise as a result of various economic measures that have a direct or indirect impact on the natural environment. Usually, effects of this kind are destructive to the vegetation of the developed territory and contribute to anthropogenic dynamic processes. In some cases (e.g. various types of forest management and agriculture), this is due to the direct use of plant resources: forest resources (wood, pine nuts, wild flora, etc.), steppe and meadow resources (hayfields and pastures), etc. In other cases, vegetation is affected by man-made and household emissions from industrial enterprises and residential areas. In addition, it is affected by the pyrogenic factor associated with targeted (man-made) burnout, commonly used in traditional land use, or non-targeted forest and steppe fires. They are typically of anthropogenic origin and are caused by

human activities: tourism, outdoor recreation, accidental use of plant resources, etc. [1].

This is largely due to the multifaceted role of vegetation in human life and economic activity. Such a role can be defined as socio-economic, as opposed to the ecological role played by vegetation in geosystems. This is, to some extent, an arbitrary distinction, since all the ecological functions of vegetation are usually considered in terms of their usefulness or danger to human interests. It is for this reason that it is important and necessary to take them into consideration in order to achieve environmental management in the region.

The ecological functions of vegetation in geosystems are manifested in the form of acceleration or deceleration of various processes in them, which ultimately determines its regulatory, transformational, and other properties. This was taken into consideration in the development of theories of biogeocenoses, geosystems, as well as natural landscape systems. Vegetation is seen as an important (often critical) component, formed through interaction with other components and factors of natural systems. It follows that there is an impact on the various processes occurring in them, as well as on their nature, modes, and time parameters.

Vegetation plays a different role, largely due to its functional characteristics, in the economy of human society [2]. Of particular importance is the fact that the economic role of vegetation depends on its ecological function, as this determines the paramount importance of their consideration in the environmental management system. The role of vegetation is directly related to its specific purpose in solving specific social and production problems.

It is advisable to define the specific roles of vegetation in these groups in accordance with specific methods of nature management related to vegetation, such as conservation, protection, resource management, etc. The ecological group is similar in its substantive definition to the group of ecological functions but the priority, in this case, is given to the expediency of using a specific function in the economy. Here, the following types of useful ecological functions of vegetation for human economic activity in a particular region are distinguished: anti-erosion, decongestant, stabilizing permafrost, emergency, anti-landslide, soil and wind protection, and others. This corresponds to the ecological functions of vegetation performed by it in natural systems, depending on the general natural and geographical features of the region [3]. Soil complexity and climatic conditions are the main factors when taking into consideration the cultivation of forest plantations. Therefore, studies on the integrated assessment of the soil and geobotanical state of land plots for the implementation of afforestation work are relevant.

2. Literature review and problem statement

A feature of geobotanical forecasting is the fact that it includes a complex self-developing autotrophic evolutionary-dynamic system, that is, the vegetation of a certain territory consisting of a wide variety of plant communities. They are an extremely important, often critical component of natural systems that perform various environment-forming, conservation, and often resource functions. Therefore, the main goal of geobotanical forecasting is to understand the composition and structure of vegetation cover and assess them from an ecological and resource point of view. It is known that geobotanical forecasting is aimed at obtaining an idea of the future structure of vegetation and assessing the possibilities of stable performance of its main functions, that is resource, environment-forming, ecosystem, landscape-protective, social, and other functions in an optimal mode. In addition, forecasting is based on information on the evolution and dynamics (spontaneous and anthropogenic) of plant communities that make up the modern vegetation cover [4].

Geobotanical forecasting always deals with the entire vegetation cover of the study area, represented by communities of vegetation of various types. All plant communities as components of geosystems of a certain territory are studied in order to identify floristic, structural-cenotic, ecological-topological, evolutionary-genetic, dynamic, and other geobotanical features of each of them. They are analyzed as a single spatial formation with a certain geographical structure (subzonal, altitudinal-zonal, regional-genetic, etc.), which arose during the evolutionary development of the natural environment and vegetation itself [5].

To summarize the latest information on the assessment of the soil and geobotanical state of land plots, we have considered published in peer-reviewed journals in the period from January 2000 to January 2020. More than 20 studies were found to meet the required conditions.

Those studies were further filtered based on the following criteria:

– research should focus exclusively on earth remote sensing applications for forest monitoring;

– studies should use remote sensing data acquired using on-board/space imagery or LIDAR;

– the use of an unmanned aerial vehicle.

Our analysis of study [6] makes it possible to conclude that activities directly in the study area produce a better picture of the state of a forestry station. In the cited work, the studies were conducted on the territory of South Bohemia. Wild plants growing in the area of the old waste warehouse of the uranium ore processing plant were considered. The paper shows the importance of studying soil samples in the laboratory.

Research into the environment in modern soils is important for understanding the geochemical processes in coastal landscapes and the rate of pedogenesis. This is shown in [7]. In the extracted soil water, 696 samples were taken from the screw holes. The study shows how important it is to apply the right choice of sampling method for work.

Paper [8] uses geobotanical and climate long-term monitoring as important tools for assessing the impact of climate change on forest dynamics. Changes in ecosystems along the altitudinal gradient were found to indicate that the climate has changed in the direction of warming and aridization (drought). That assumption was also confirmed by the analysis of regional climate data over the past 60 years, which showed an increase in air temperature by 1.8 °C and a decrease in precipitation by more than 100 mm. The study showed that the most stable types of forest vegetation were cedar-larch forests of the upper forest belt and cedar subalpine forests.

Our analysis of work [9] indicates that the contribution of roots, litter, and soil microorganisms in urban forest ecosystems is advantageous to the method of digging a trench to assess seasonal dynamics. The results showed that digging trenches could significantly increase soil moisture and reduce microbial activity.

In work [10], an analysis of the methodology of geobotanical forecasting is carried out. A close relationship between

geobotanical forecasting and vegetation mapping has been demonstrated. To improve the objectivity of the results, cartographic models of modern and predicted vegetation were used, which most fully reflect the entire structural and cenotic diversity of plant communities in the Baikal region, the central region of Baikal Siberia.

Our analysis of work [11] indicates that changes in the soil macrofauna community in burned forests can be reflected in the ratio of various functional features that have recently been proposed for several groups of terrestrial organisms. The effect of heterogeneity within the burned area overshadows the effect of its size. Although there are groups such as earthworms that have a limited ability to settle, their numbers in burned areas of different sizes were comparable. The recovery of soil organisms after a fire is probably related to the density of vegetation cover and the thickness of the remaining organic layer.

Paper [12] reports the results of the evaluation stage of forecast and cartographic studies into the vegetation of the Angara-Lena interfluve. An assessment of the main and secondary ecological functions of vegetation within geosystems is given. The paper demonstrates changes in relation to local (reconstructed) vegetation.

Due to the peculiarity of the location and climatic indicators, the considered research methods are not applicable to the territories of Kazakhstan. The territory is for the most part a flat slightly wavy plain with a wide development of westerns and a less wide distribution of large weakly deep depressions occupied by swamps and lakes. The region is crossed by the hollow of the Iman-Burluk log. The climate of the zone is strongly influenced by the continental air of East Siberian origin, which prevails here and establishes fairly stable and dry weather. On the other hand (especially in the summer), it experiences a significant influence of air coming from the Atlantic, bringing the bulk of the annual rainfall. At the same time, in the summer, there are frequent invasions of cold Arctic air, which, when moving to the south, acquires the properties of dry wind. In the same season, there is also an intake of dry and highly overheated air from the south from the regions of Central Asia. The result is a sharply continental climate with harsh winters and fairly hot summers, compared to the northern forest-steppe. In the soil cover in areas not covered by forest, the predominant soils are saline systems on quaternary sediments. Under the feather-grass vegetation, there is a subzone of black soils of ordinary medium humus, under feather-tipchak – a subzone of southern chernozems with saline systems on quaternary sediments, which are divided into genera: non- solonetzic, solonetzic, tongue, carbonate, and underdeveloped, as well as in types: powerful ($A+B$ more than 80 cm), increased power ($A+B$ within 70–80 cm), medium power (A+B within 45–70 cm), reduced power ($A+B$ within 30–45 cm), and low-power ($A+B$ less than 30 cm).

Taking into consideration all the advantages of the above studies, a methodology for studying three forestry stations was devised: Kamysh, Burluk, and Nagorny.

3. The aim and objectives of the study

The purpose of this study is to identify the area of plots suitable for all major forest species, the area of plots with existing forests, forest crops, and overgrown with self-sowing.

This will provide an opportunity for tillage of the soil for forest crops and the implementation of subsequent agricultural techniques.

To accomplish the aim, the following tasks have been set:
– to describe land plots and identify types of plant associations;
– to conduct chemical analyses of soil samples;
– to devise recommendations for land plots.

4. The study materials and methods

Agricultural techniques in the creation of forest crops are of great importance. Agrotechnical methods of the first stage are the preparation of forest areas for planting and tillage of the soil for forest crops. Studying the soil determines whether the soil has enough available nutrients for plants. That also makes it possible to monitor changes in soil properties, which, one way or another, affect the growth and development of plants.

The research methodology was implemented in relation to three forestry stations: Kamysh – 196.2 hectares, Burluk – 131.0 hectares, Nagorny – 78.3 hectares (North Kasazstan region, Republic of Kazakhstan).

Satellite photos of the sites are shown in Fig. 1–3. The vegetation was studied by laying accounting sites with a size of 1 m² on a mechanical basis, involving determining plant species and abundance on them according to the Drude scale.

Soil sections are laid in areas with typical ground cover after a reconnaissance route-loop survey of the territory. The homogeneity of the soils within the soil contours is confirmed by the laying of excavations in approximate boundaries determined by plant associations.
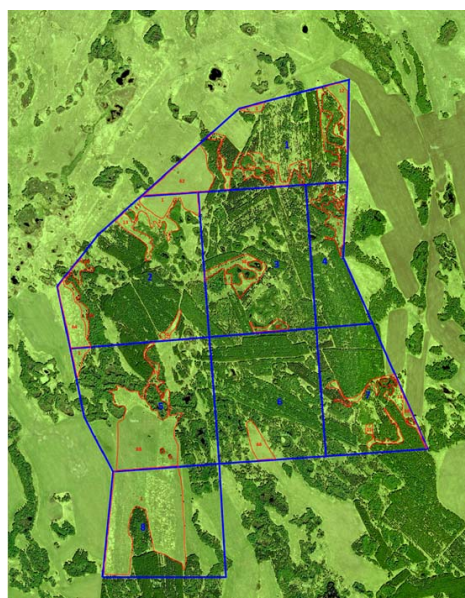

Fig. 1. Satellite image of the studied land plots in the Kamysh forestry station

We studied the soil by the method of laying soil sections and semi-pits with a description of the power of the horizons in centimeters, color, structure, addition, well presence, soil density, the existence of soil new formations and inclusions. The depth of the soil sections is up to the soil-forming rock.

Fig. 2. Satellite image of the surveyed land plots in the Burluk forestry station

Fig. 3. Satellite image of the surveyed land plots in the Nagorny forestry station

To unify determining a soil color, a Zakharov triangle of colors was used. The structure of the soil was determined by the method of breaking down soil samples.

The addition of the soil was determined by field studies on the resistance to the indentation of the knife throughout the depth of the soil pit with the division into loose, compacted, dense.

Soil well presence was determined by the size of the pores and the width of the interstructural cracks with the division into fine-porous (pore diameter less than 1 mm), porous (more than 1 mm), finely cracked (with a crack width of less than 3 mm), and fractured (more than 3 mm).

Porosity was taken on the basis of determining the mechanical composition of the soil according to reference data. For clay – 44–50 %, coarse sand, gravel – 36–42 %, sand – 35–40 %.

We determined the granulometric composition by the wet method with a division into sand, loam, light loam, medium loam, heavy loam, and clay.

The chemical analysis of soil samples was carried out at the certified laboratory of the Department of Land Cadaster and Technical Inspection of Real Estate of the Republic of Kazakhstan.

Easily soluble salts, even with a small content in the soil, adversely affect the growth of woody plants. Salts affect plants not only through osmotic pressure but also directly, showing a toxic effect. The toxicity of salts is expressed in chlorine equivalents. If we take the toxicity of chlorine as a unit, the toxicity of sodium bicarbonate ($NaHCO_3$) is 3 times less, and sodium sulfate is 6 times less than the toxicity of NaCl. Consequently, the most harmful and infertile for plants will be soda salt marshes, then chloride, and the least dangerous – sulfate salt marshes. At the same time, the most harmful are sodium carbonates (the maximum permissible limit of the content is 0.005 % with insufficient moisture and 0.01 % with moderate moisture).

Summarizing the data available in the literature, the maximum magnesium content with the predominance of chlorides in the composition of the aqueous extract anions is 1.5 mg-equiv./100 g, with the predominance of sulfates – 2.0 mg-equiv./100 g.

The solonetzic degree is characterized by a fraction expressed as a percentage of the exchange capacity, which among the exchange cations is occupied by exchange sodium:
– 3–10 % – slightly solonetzic soil;
– 10–15 % – medium solonetzic soil;
– 15–20 % – strongly solonetzic soil;
– 20–25 % – low solonetzic salt marsh;
– 25–40 % – medium solonetzic salt marsh;
– over 40 % – highly solonetzic solonetz.

5. Results of studying forestry stations

5. 1. Description of land plots and identification of types of plant associations

During the reconnaissance route-loop survey of the land plots in the Kamysh forestry station, 3 types of plant associations were identified.

The first type of plant association is a cereal grass with an admixture of wormwood, marked on the allotments used for pastures and hayfields.

The second type of plant association is richly multi-grass open spaces, used as hayfields and, at the time of the survey, having a low regrowing grass stand, or without economic use with a high grass stand.

The third type of plant association was noted only on one of the allotments surveyed in this forestry station (quarter 3 of allotment 58); it is a sagebrush-cereal grass with a large number of salinity indicators.

During the reconnaissance route-loop survey of land plots in the Burluk forestry station, 3 types of plant associations were identified.

In the clearings between the forests and in some open spaces, mainly in the northern and eastern parts, feather-grass associations are noted, partially used for hayfields. At the same time, wormwood – indicators of salinity - are present in single quantities scattered.

The second type is cereal-multi-grass associations with an admixture of wormwood.

The third species is found mainly along the Iman-Burluk River, which is a feather-sagebrush association with ubiquitous rock outcrops. Incisions are laid on all three types of plant associations. Excavations in other allotments confirmed the analogy of soil morphology.

During the reconnaissance route-loop survey of the land plots in the Nagorny forestry station in uncovered forest areas, 1 type of plant association was identified. The section is laid in the allotment 21 of quarter 14. The vegetation is a feather-grass rich-grass association with a small admixture of wormwood. There are forest crops at the site.

5. 2. Chemical analysis of soil samples

The plot of allotment 1, quarter 8, in the Kamysh forestry station is an area with a strong influence of anthropogenic factors. Part of the allotment is used for haying, part for pasture. Directly during the survey, a herd of cattle grazed on the allotment. This affects the ground cover. The total coverage with grassy vegetation is 90–95 %.

The vegetation has clear traces of strong anthropogenic impact. There are spots and even tongues of salt marshes along the lowlands, on average 2–3 % of the area. The average height of the grass stand in the mowed areas is about 15 cm, on the unmowed – 30–35 cm. It is dominated by tipchak (40 %), meadow fescue (40 %), green strawberry (5 %), field thistle (5 %), meadowsweet (5 %), Austrian wormwood (5 %).

A description of the soil structure of the site according to the field study of the soil section is given in Table 1.

Based on the chemical analysis of soil samples according to Table 2, it was found that the humus content is high: at horizon A – 5.0 %. In the composition of the absorbed bases, the amount of exchange sodium at horizon AB is 0.4 %, at horizon B – 7.47 %, at horizon BC – 9.17 %, which characterizes the soil as weakly solonetzic. There are no soluble carbonates. The amount of bicarbonates is low. The amount of chlorides is increased. The volume of sulfates is high (the maximum permissible content is 0.3 %). The volume of magnesium ions toxic to wood species is high. Calcium predominates in the composition of water extract cations at horizon A, and sodium prevails in the underlying ones. The soil is weakly acidic at horizon A, in the depths – alkaline. With depth, the pH changes unevenly. By the volume of salts, horizons A and AB are unsalted, B and BC are weakly saline.

The plot in allotment 62, block 1, in the Kamysh forestry station on the ground cover contains richly multi-grass plant associations with a minimum amount of wormwood. The total coverage of grassy vegetation is 100 %.

The vegetation has clear traces of strong anthropogenic impact. The average height of the grass stand is 35–40 cm. It is dominated by meadow fescue (80 %), green strawberry (10 %), Marshal's carrot (5 %), meadowsweet (3 %), and Austrian wormwood (2 %).

To characterize the soil profile of the site, Table 3 describes section No. 2.

Based on the chemical analysis of soil samples according to Table 4, it was found that the humus content is high: at horizon A – **5.7 %.** In the composition of the absorbed bases, the volume of exchange sodium at horizon AB is 0.33 %, at B – 3.5 %, which characterizes the soil as weakly solonetzic. There are no soluble carbonates. The amount of bicarbonates is increased. The quantity of chlorides is small. The quantity of sulfates is extremely low. In the composition of cations of water extraction at horizons A and AB calcium predominates, below - sodium. The soil on the entire profile is alkaline. With depth, the pH increases. By the volume of salts, the studied soil profile is unsalted.

Table 1

Description of the soil structure of the site according to the field study of soil section No. 1

	Horizon A0 from 0 to 2 cm	Dry grass (steppe felt)
	Horizon A from 2 to 20 cm	Dark gray, almost black. Ubiquitous inclusions of grass roots, the number of which decreases to the bottom. Compacted. Dry. Finely lumpy dusty. Finely cracked. Medium loam. pH 6.7. The transition to the next horizon is gradual
	Horizon AB from 20 to 84 cm	Brown with a combination of pronounced and blurred dark gray strips. Large-lumpy. Dry. Compacted. Medium loam. pH 8.1. The transition to the next horizon is gradual
	Horizon B from 84 to 173 cm	Brown. Below 140 cm, there are quartz inclusions. Large-lumpy. Dense. Fresh, wet to the bottom. Heavy loam. pH 8. Boils violently under the influence of hydrochloric acid
	Horizon BC below 173 cm	Brown with gray lenses. Viscous plastic. Wet. Clay. pH 8.1. Boils violently under the influence of hydrochloric acid

Table 2

Data from the chemical analysis of soil samples for allocation 1, block 8, in the Kamysh forestry station

No	Indicator	Horizon A	Horizon AB	Horizon B	Horizon BC
1	Absorption capacity	24.96 mg-equiv./100 g soil	24.96 mg-equiv./100 g soil	23.04 mg-equiv./100 g soil	19.2 mg-equiv./100 g soil
2	The volume of hydrocarbons	0.0232 %	0.0397 %	0.0336 %	0.0317 %
3	Quantity of chlorides	0.0064 %	0.0075 %	0. 0.0089 %	0.0149 %
4	The volume of sulfates	0.0024 %	0.0024 %	0.0168 %	0.204 %
5	The amount of magnesium ions toxic to tree species	0.2 mg-equiv./100 g	0.2 mg-equiv./100 g	0.96 mg-equiv./100 g	0.96 mg-equiv./100 g
6	Sum of salts	0.0435 %	0.0689 %	0.2949 %	0.3619 %

Table 3

Description of the soil structure of the site according to the field study of soil section No. 2

	Horizon A0 from 0 to 5 cm	Dry grass (steppe felt)
	Horizon A from 5 to 27 cm	Black. Ubiquitous inclusions of grass roots, the number of which decreases to the bottom. Loose. Dry. Finely lumpy dusty. Lots of rodent burrows. Medium loam. pH 7.1. The transition to the next horizon is gradual
	Horizon AB from 27 to 82 cm	Brown, with very strongly blurred gray tongues and abundant white-eyed. In some places, there are large spots and streaks of white eye. Finely lumpy. Fresh. Compacted. There is a rodent burrow. Medium loam. pH 7.9. It boils violently under the influence of hydrochloric acid. The transition to the next horizon is gradual
	Horizon B from 82 to 169 cm	Brown. Large-lumpy. Extremely dense. Fresh. Heavy loam. pH 8.5. Boils violently under the influence of hydrochloric acid

Table 4

Data from the chemical analysis of soil samples for allocation 62, block 1, in the Kamysh forestry station

No	Indicator	Horizon A	Horizon AB	Horizon B
1	Absorption capacity	26,88 mg-equiv./100 g	26,88 mg-equiv./100 g	18,88 mg-equiv./100 g soil
2	The volume of hydrocarbons	0,0232 %	0,0397 %	0,0531 %
3	Quantity of chlorides	0,0075 %	0,0397 %	0,0114 %
4	The volume of sulfates	0,048 %	0,048 %	0,0024 %
5	The amount of magnesium ions toxic to tree species	0,22 mg-equiv./100 g	0,22 mg-equiv./100 g	0,16 mg-equiv./100 g
6	Sum of salts	0,0474 %	0,0685 %,	0,0985 %

Section No. 3 is laid in block 3 of allotment 58 in the Kamysh forestry station as it has a sagebrush-grass cover with a large number of salinity indicators. In the northern and central part, there are dead cultures of birch and maple, individual trees and biogroups have been preserved.

Total coverage – 100 %. It is dominated by the sprawling beskilnitsa (55 %), tipchak (20 %), Austrian wormwood (20 %), green strawberries (3 %), and Gmelin's kermek (2 %).

To characterize the soil profile of the site, Table 5 describes section No. 3.

Table 5

Description of the soil structure of the plots according to the field study of soil section No. 3

	Horizon A0 0–2 cm	Dry grass (steppe felt)
	Horizon A from 2 to 33 cm	Grey. It is full of plant roots. Large-lumpy cracked. Compacted. Medium loam. pH 7.7. The transition to the next horizon is gradual
	Horizon AB from 33 to 85 cm	Heterogeneous brown with a combination of clear and strongly blurred gray tongues. Lots of white-eye inclusions. Dense. Large lumpy with lumps. Dry. Medium loam. pH 8.4. It boils violently under the influence of hydrochloric acid. The transition to the next horizon is gradual
	Horizon B from 85 to 170 cm	Brown. Fresh. Very dense. Large-lumpy. Heavy loam. pH 8.9. Boils violently under the influence of hydrochloric acid

Based on the chemical analysis of soil samples according to Table 6, it was established that the humus content is average: at horizon A – 3.9 %. In the composition of the absorbed bases, the volume of exchange sodium at horizon A is 12.01 %, at AB – 18.13 %, at horizon B – 31.6 %, which characterizes the soil as medium solonetzic solonetz. The sum of dissolved salts at horizon A **is** low. According to the degree of salinity and the presence of salts, the soil is medium-saline. No soluble carbonates have been detected. The volume of bicarbonates is average. The volume of chlorides is increased. The volume of sulfates is extremely high, at horizon B it exceeds the maximum permissible value of 0.3 %. The volume of magnesium ions toxic to wood species is high. The composition of the cations of the aqueous extract is dominated by sodium. The soil is alkaline, with the depth the pH increases.

Table 6

Chemical analysis data of soil samples for block 3, allotment 58, in the Kamysh forestry station

No	Indicator	Horizon A	Horizon AB	Horizon B
1	Absorption capacity	27.97 mg-equiv./100 g soil	18.13 mg-equiv./100 g soil	16.01 mg-equiv./100 g soil
2	The volume of hydrocarbons	0.0146 %	0.036 %	0.0592 %
3	Quantity of chlorides	0.0078 %	0.0085 %	0.0149 %
4	The volume of sulfates	0.0168 %	0.2313 %	0.3391 %
5	The amount of magnesium ions toxic to tree species	0.3 mg-equiv./100 g	0.32 mg-equiv./100 g	1.12 mg-equiv./100 g
6	Sum of salts	0.0657 %	0.3278 %	0.553 %

The section is laid in allocation 1, block 2, in the Burluk forestry station. The vegetation is a feather-grass association. There is abundant self-sowing of pine. Most of the allotment is used for hayfields. On the hayfield, damaged self-sowing of pine was also noted.

The average height of the grass stand in unmowed areas is about 40 cm, in mowed areas – about 10 cm. Feather grass dominates (the species is difficult to determine in October, possibly red) (75 %), along the forest – fescue meadow (10 %), field thistle (5 %), green strawberry (5 %), yarrow (3 %), Austrian wormwood (2 %).

To characterize the soil profile of the site, Table 7 describes section No. 4.

Table 7

Description of the soil structure of the site according to the field study of soil section No. 4

	Horizon A0 from 0 to 1 cm	Dry grass (steppe felt)
	Horizon A from 1 to 36 cm	Black. Many pebbles of granite with a diameter of up to 5 mm. Ubiquitous inclusions of grass roots, the number of which decreases to the bottom. Compacted. Dry. Finely lumpy dusty. Medium loam. pH 7.6. The transition to the next horizon is gradual
	Horizon AB from 36 to 85 cm	Brown, with very strongly blurred black tongues and abundant inclusions of white-eyed, in some places merging into veins and tongues. Finely lumpy. Dry. Very dense. Medium loam. pH 7.9. It boils violently under the influence of hydrochloric acid. The transition to the next horizon is gradual
	Horizon B from 85 to 181 cm	Brown. Large-lumpy. Extremely dense. Fresh. Heavy loam. pH 8.6. Boils violently under the influence of hydrochloric acid

Based on the chemical analysis of soil samples according to Table 8, it was established that the humus content is average: at horizon A – 3.9 %. The absorption capacity is high. In the composition of the absorbed bases, the amount of exchange sodium at horizon AB is 0.28 %, at horizon B – 3.87 %, which characterizes the soil as weakly solonetzic. There are no soluble carbonates. The volume of bicarbonates is increased. The volume of chlorides is low. The volume of sulfates is extremely low. In the composition of cations of water extract at horizon A and AB, calcium predominates, below – sodium. The soil on the entire profile is alkaline. With depth, the pH increases. By the volume of salts, the soil profile is unsalted.

Table 8

Data from the chemical analysis of soil samples for allocation 1, quarter 2, in the Burluk forestry station

No	Indicator	Horizon A	Horizon AB	Horizon B
1	Absorption capacity	28.8 mg-equiv./100 g soil	28.8 mg-equiv./100 g soil	21.44 mg-equiv./100 g
2	The volume of hydrocarbons	0.0287 %	0.0384 %	0.0573 %
3	Quantity of chlorides	0.0075 %	0.0075 %	0.0075 %
4	The volume of sulfates	0.0048 %	0.0048 %	0.0048 %
5	The amount of magnesium ions toxic to tree species	0.28 mg-equiv./100 g	0.2 mg-equiv./100 g	0.12 mg-equiv./100 g
6	Sum of salts	0.0543 %	0.0675 %	0.0982 %

The section was laid in allotment 6, quarter 11, in the Burluk forestry station. This and adjacent areas contain cereal-multi-grass associations with an admixture of wormwood. There are newly laid pine crops at this allotment.

The total coverage of grassy vegetation is 90 %; there are overgrown furrows. The average height of the grass stand is 40 cm. It is dominated by meadow fescue (55 %), common carrot (15 %), yellow alfalfa (10 %), and large green strawberry curtains (10 %). Singular or small curtains mark common yarrow (3 %), field thistle (3 %), elm (2 %), Sivers wormwood (1 %), and meadowsweet (1 %).

To characterize the soil profile of the site, Table 9 describes section No. 5.

Based on the chemical analysis of soil samples according to Table 10, it was found that the humus content is very high: at horizon A – 8.9 %. The absorption capacity is high. In the composition of the absorbed bases, the amount of exchange sodium at horizon A is 0.18 %, at horizon AB – 0.51 %, at horizon B – 4.8 %, at horizon C – 10.47 %, which characterizes the soil as medium solonetzic. Soluble carbonates are present, the volume of carbonates is extremely high but below the maximum permissible value (0.01 %). The volume of bicarbonates is average. The volume of chlorides is average. The volume of sulfates is low. The volume of magnesium ions toxic to wood species is low. In the composition of cations of water extraction at horizons A and AB, calcium predominates, below – sodium. The soil on the entire profile is alkaline. With depth, the pH increases. By the volume of salts, the soil profile is unsalted.

Section No. 8 is laid in block 7 of allotment 6 in the Burluk forestry station. This and adjacent allotments are located on the bank of the Iman-Burluk River and are an open space with a noticeable slope towards the river, bounded on the west by the riverbed, on the north, south, and south-east by forests. In this area, the ground cover is sharply different from all other areas in this forestry and represents a feather-sagebrush association with ubiquitous rock outcrops.

Table 9

Description of the soil structure of the site according to the field study of soil section No. 5

Horizon A0 from 0 to 1 cm	Dry grass (steppe felt)
Horizon A from 1 to 15 cm	Black. It is very densely saturated with plant roots. Fine-grained. Compacted. Dry. Medium loam. pH 7.4. The transition to the next horizon is gradual. Slightly boils under the influence of hydrochloric acid
Horizon AB from 15 to 110 cm	Heterogeneous, light brown with blurry dark tongues. Lots of roots at the top of the horizon. Dense. Finely lumpy nutty. Dry. Medium loam. pH 8.4. The transition to the next horizon is weakly gradual. Boils violently under the influence of hydrochloric acid
Horizon B from 110 to 166 cm	Brown, it gets dark towards the bottom. Fresh. Very dense. Large lumpy with lumps. Heavy loam. pH 8.9. It boils violently under the influence of hydrochloric acid. The transition to the next horizon is weakly pronounced
Horizon C below 166 cm	Dark brown. Wet. Compacted. Large-lumpy. Clay. pH 9. Boils violently under the influence of hydrochloric acid

Table 10

Data from the chemical analysis of soil samples for allocation 6, quarter 11, in the Burluk forestry station

No	Indicator	Horizon A	Horizon AB	Horizon B	Horizon C
1	Absorption capacity	33.91 mg-equiv./100 g	27.2 mg-equiv./100 g	22.49 mg-equiv./100 g	16.91 mg-equiv./100 g
2	The volume of hydrocarbons	0.0128 %	0.0287 %	0.0366 %	0.0537 %
3	Quantity of chlorides	0.0075 %	0.0092 %	0.0117 %	0.0146 %
4	The volume of sulfates	0.0072 %	0.0048 %	0.0264 %	0.0288 %
5	The amount of magnesium ions toxic to tree species	0.22 mg-equiv./100 g	0.2 mg-equiv./100 g	0.22 mg-equiv./100 g	0.26 mg-equiv./100 g
6	Sum of salts	0.0364 %	0.0611 %	0.1071 %	0.1415 %

The total coverage is 85 %. An abundance of burrows of small rodents and lizards was noted. It is dominated by feather grass (65 %), green strawberry (15 %), common carrot (5 %), creeping thyme (5 %), scattered dandelion (5 %), Austrian wormwood (5 %).

On the site, especially in the places of granite outcrops, there is self-sowing of birch and pine. The depth of the soil in different areas is different, from 0 cm (rock outcrop on the surface). In the middle part of the site where the section is laid – 92 cm.

To characterize the soil profile of the site, Table 11 gives a description of section No. 6.

Table 11

Description of the soil structure of the plots according to the field study of soil section No. 6

	Horizon $A0$ 0–1,5 cm	Dry grass (steppe felt)
	Horizon A from 1,5 to 17 cm	Gray. Grainy. Loose. Dry. Sandy loam. pH 7.4. The transition to the next horizon is gradual
	Horizon $B1$ from 17 to 37 cm	Yellow. Compacted. Grainy. Fresh. Sandy loam. pH 7.6. Boils under the influence of hydrochloric acid. The transition to the next horizon is faintly distinct
	Horizon B from 37 to 92 cm	Brown. A large number of inclusions of white-eye and quartz particles measuring 2–3 mm. Moistened. Compacted. Finely lumpy. Light loam. It boils when exposed to hydrochloric acid. pH 7.6
	Below 92 cm	Granite grit and rock base

Based on the chemical analysis of soil samples according to Table 12, it was found that the humus content is average: at horizon A – 3.9 %.

The absorption capacity is high. In the composition of the absorbed bases, the amount of exchange sodium at horizon A is 0.24 %, at $B1+B2$ – 2.58 %, which characterizes the soil as not solonetzic. According to the degree of salinity and the presence of salts, the soil is medium saline. There are no soluble carbonates. The volume of bicarbonates is low, it decreases with depth. The volume of chlorides is average, increasing with depth. The volume of sulfates is very high. The volume of magnesium ions toxic to wood species is high. Calcium predominates in the composition of cations of water extract. The soil is alkaline on the entire soil profile; with depth, the pH increases.

Table 12

Data from the chemical analysis of soil samples for block 7 of allotment 6 in the Burluk forestry station

No	Indicator	Horizon A	Horizon $B1+B2$
1	Absorption capacity	29.12 mg-equiv./100 g	23.68 mg-equiv./100 g
2	The volume of hydrocarbons	0.0305 %	0.0238 %
3	Quantity of chlorides	0.0089 %	0.0138 %
4	The volume of sulfates	0.0048 %	0.4272 %
5	The amount of magnesium ions toxic to tree species	0.32 mg-equiv./100 g	1.8 mg-equiv./100 g
6	Sum of salts	0.06 %	0.6626 %

The section is laid in allotment 21, quarter 14, in the Nagorny forestry station. The vegetation is a feather-grass rich-grass association with a small admixture of wormwood. There are forest crops at the site.
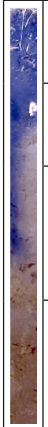
According to the structure and chemical analysis, the soil type is southern medium-saline chernozem on a rock base. It is suitable for all major forest-forming species. The light mechanical composition of the entire soil profile makes it possible to recommend a site for planting coniferous species.

The dominant plants are Lessing's feather grass (45 %), creeping wheatgrass (30 %), field thistle (10 %), elm (5 %), common yarrow (5 %), Austrian wormwood (2 %), Sievers wormwood (2 %), and common wormwood (1 %) along the roads. Numerous mole holes have been noted.

To characterize the soil profile of the site, Table 13 describes section No. 7.

Table 13

Description of the soil structure of the site according to the field study of soil section No. 7

	Horizon $A0$ from 0 to 3 cm	Dry grass (steppe felt)
	Horizon A from 3 to 28 cm	Black. Heavily sodden. Dense. Dry, finely lumpy. Medium loam. pH 7.4. The transition to the next horizon is gradual
	Horizon AB from 28 to 77 cm	Light brown with broad blurred black tongues. Finely lumpy. Fresh. Dense. Medium loam. pH 7.7. Boils under the influence of hydrochloric acid. The transition to the next horizon is noticeable
	Horizon B from 77 to 167 cm	Brown. Finely lumpy. Extremely dense. Fresh on top, moistened to bottom. Medium loam. pH 8. Boils violently under the influence of hydrochloric acid

Based on the chemical analysis of soil samples according to Table 14, it was found that the humus content is high: at horizon A – 5.3 %.

Table 14

Data from the chemical analysis of soil samples for allocation 21, block 14, in the Nagorny forestry station

No	Indicator	Horizon A	Horizon AB	Horizon B
1	Absorption capacity	31.36 mg-equiv./100 g	31.36 mg-equiv./100 g	22.08 mg-equiv./100 g
2	The volume of hydrocarbons	0.0336 %	0.0329 %	0.0348 %
3	Quantity of chlorides	0.0089 %	0.0064 %	0.0075 %
4	The volume of sulfates	0.0024 %	0.0024 %	0.0024 %
5	The amount of magnesium ions toxic to tree species	0.2 mg-equiv./100 g s per horizon	0.24 mg-equiv./100 g	0.26 mg-equiv./100 g
6	Sum of salts	0.0612 %	0.0553 %	0.058 %

The absorption capacity is very high. In the composition of the absorbed bases, the amount of exchange sodium at horizon AB is 0.22 %, at horizon B – 0.45 %, which characterizes the soil as not solonetzic. By the volume of soluble salts, the studied soil profile is unsalted. There are no soluble carbonates. The volume of bicarbonates is low. The volume of chlorides is low. The volume of sulfates is extremely low on the entire soil profile studied. The volume of magnesium ions toxic to wood species is low. In the composition of cations of water extract on the entire studied soil profile, calcium predominates. The soil is alkaline. With depth, the pH increases.

5. 3. Devising recommendations for land plots

Land plots are located within the steppe zone of the Kazakh small hills, in the forest-steppe belt of the stepped upland island and foothill-plain forests in the area of Kokshetau-Munchakta hill lands and rocky small hills. The surveyed state forestry stations are located in the subdistrict of the North Kokshetau stepped birch indigenous, steppe pines and derived pine forests.

This area is characterized by the distribution of the remaining lowlands of the hilly-ridge and hilly-basin small hills and basement plains composed of pre-Paleozoic and Paleozoic sedimentary and igneous rocks (granite, quartzite, limestone, etc.).

The devised recommendations based on the results of our study are given in Tables 15–17.

Table 15

For the land plots in the Kamysh forestry station

Area category	Quarter	Allocated area	Area, ha	Research results and recommendations
Arable land	1	1	1.4	Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Arable land	1	9	5.0	On the site, there are forest crops (≈2 hectares) and numerous self-sowing of birch, in some places quite large curtains. Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Grassland	1	12	3.9	Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Grassland	1	28	10.4	On the site, there are forest crops (≈1 ha) and numerous self-sowing of birch, in some places quite large curtains. Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Arable land	1	62	15.6	Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Arable land	2	1	6.8	Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Grassland	2	2	3.4	Chernozem is slightly solonetzic. Suitable for all major forest-forming species. On the allotment, there is a large self-sowing of birch, in some places quite large curtains
Grassland	2	13	3.5	Chernozem is slightly solonetzic. Suitable for all major forest-forming species. On the allotment, there is a large self-sowing of birch, in some places quite large curtains
Grassland	2	45	2.0	Chernozem is slightly solonetzic. Suitable for all major forest-forming species. On the allotment, there is a large self-sowing of birch, in some places quite large curtains
Arable land	2	64	9.5	Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Grassland	2	65	2.5	Chernozem is slightly solonetzic. Suitable for all major forest-forming species. A lot of self-sowing of birch
Grassland	2	70	2.0	Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Grassland	3	58	5.7	In the northern and central part, there are dead crops of birch and maple, individual trees and biogroups have been preserved – the soil is the medium solonetzic sulfate-magnesium solonetz (3.8 hectares). It is unsuitable for the main forest-forming species of the region. The southern part of the site (1.7 hectares) is slightly solonetzic chernozem. At the southern end, there are forest birch crops with an area of 0.2 hectares
Grassland	3	97	2.7	Most of the allotment is birch crops with good preservation (≈2.4 hectares). There are several open areas with a total area of 0.3 hectares. Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Grassland	4	3	8.7	At the plot, there are birch crops (4 hectares). The preservation is not the same; on part of the allotment (4.7 hectares), the crops died, apparently, as a result of a grassroots fire. Only single trees and biogroups have been preserved in these areas. Reconstruction is needed. Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Arable land	5	1	3.0	Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Grassland	5	35	4.0	Chernozem is slightly solonetzic. Suitable for all major forest-forming species. At the allotment, there is a large self-sowing of aspen and birch, in some places quite large curtains
Grassland	5	88	33.0	Chernozem is slightly solonetzic with spots and tongues of salt marshes (3–5 % of the territory). Suitable for all major forest-forming species
Grassland	6	66	4.6	Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Grassland	7	13	8.3	At the allotment, in the north-eastern part, there is a swampy area overgrown with willow (≈0.6 hectares). There is also a large self-sowing of birch, in some places quite large curtains. Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Arable land	7	30	3.5	Chernozem is slightly solonetzic. Suitable for all major forest-forming species. On part of the allotment, there is arable land (flax culture), under the forest on the unplowed part, there is a lot of self-sowing of birch
Grassland	7	35	2.7	Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Arable land	8	1	54.0	Chernozem is slightly solonetzic. Suitable for all major forest-forming species

Table 16

For the land plots in the Burluk forestry station

Area category	Quarter	Allocated area	Area. ha	Research results and recommendations
Grassland	1	8	2.6	Chernozem is slightly solonetzic. Suitable for all major forest-forming species. Along the forest, pine self-seeding
Grassland	1	14	2.1	Scots pine cultures aged about 12–15 years. Left fire breaks are abundantly overgrown with self-sowing pine
Grassland	2	1	23.2	Chernozem is slightly solonetzic. Suitable for all major forest-forming species. Along the forest, especially on the south side, there is abundant self-sowing of pine. Since the allotment is used as a hayfield, part of the self-sowing of pine is regularly mowed
Grassland	7	4	13.4	Chernozem is southern on a rock base. Suitable for all major forest-forming species
Grassland	7	6	2.9	Southern chernozem is medium solonetzic on a rock base. Suitable for all major forest-forming species
Grassland	7	18	5.0	Southern chernozem is medium solonetzic on a rock base. Suitable for all major forest-forming species
Grassland	7	23	3.3	Southern chernozem is medium solonetzic on a rock base. Suitable for all major forest-forming species
Grassland	9	18	4.5	Most of the allotment is occupied by Scots pine about 12–15 years old. Chernozem is slightly solonetzic. Suitable for all major forest-forming species
Grassland	9	28	8.4	Chernozem is slightly solonetzic. Suitable for all major forest-forming species. There is self-sowing of pine and birch
Grassland	11	6	15.2	On most of the allotment are the newly laid crops of Scots pine. Chernozem is medium solonetzic. Suitable for all major forest-forming species
Grassland	11	11	2.0	Chernozem is medium solonetzic. Suitable for all major forest-forming species. A lot of self-sowing pine
Grassland	11	20	6.7	Chernozem is medium solonetzic. Suitable for all major forest-forming species. A lot of self-sowing pine
Grassland	13	1	41.7	Chernozem is southern on a rock base. Suitable for all major forest-forming species

Table 17

For the land plots in the Nagorny forestry station

Area category	Quarter	Allocated area	Area, ha	Research results and recommendations
Arable land	14	21	19.6	Common chernozem. Suitable for all major forest-forming species. In the northern part of the allotment, there are forest crops (≈3.7 ha)
Arable land	15	12	27.5	Common chernozem. Suitable for all major forest-forming species. In the eastern and central part of the allotment, there are forest crops with a total area (≈1.7 hectares)
Arable land	16	1	19.2	Common chernozem. Suitable for all major forest-forming species. In the northern part of the allotment, there are forest crops (≈11.4 ha)
Arable land	16	21	12.0	Common chernozem. Suitable for all major forest-forming species

On all varieties of soils, there are various forms of solonetz and salt marshes, occupying depressions of microrelief, the proportion of which can be up to 30–40 % of the total area. They are clearly distinguished by plant associations since there is no herbaceous vegetation on them, the surface is covered with a white layer of salt, and halophytes grow sparsely around them.

6. Discussion of results of the ecological and geographical research

The territory of the North Kazakhstan region has a wide variety of soil types, which necessitates their analysis to identify favorable sites for planting crops. A comprehensive ecological and geographical study of forestry stations was carried out to proceed with work on afforestation.

The results of the forestry station study formed the basis for an improved methodology for organizing and monitoring forests. Moreover, this approach makes it possible to identify changes in the state of land and assess these changes. In addition, based on the results, it is possible to make a forecast and devise a number of recommendations for the prevention and elimination of the consequences of negative processes.

As a result, 405.5 hectares of land were surveyed in three forestry stations: Kamysh – 196.2 hectares, Burluk – 131.0 hectares, Nagorny – 78.3 hectares. In other words:

– the area of plots suitable for all major forest species is 352.9 hectares;

– the area of plots unsuitable for the main forest species is 3.8 hectares;

– the area of plots with existing forests/forest crops/overgrown with self-sowing is 48.8 hectares;

– the land plots are described and the types of plant associations are defined;

– the chemical analyses of soil samples are conducted;

– the recommendations for land plots are devised.

Basically, the identification of types of plant associations has made it possible to conduct a preliminary assessment

on the ground about the quality of the studied areas for the restoration of forest areas. Direct chemical analysis in all cases only confirmed the assumptions that arose about the qualitative composition of the studied soils. Thus, general recommendations were devised in the direct conduct of surveys on the ground; however, the systematic monitoring, using remote sensing methods of the Earth, could facilitate the ongoing research.

It should be noted that without the introduction of modern remote monitoring systems in forestry stations at all levels, full accounting and management of forest resources is impossible. More than 12 % of the plots submitted for survey under the forestry plan already had closed stands of self-sowing or forest crops. Under the current conditions of staff reduction, reduction of norms for the issuance of fuel and lubricants, and an increase in the area of bypasses, there is no real-time information on the current state of the state forest fund.

A given procedure is sensitive to a sharp change in climatic conditions and hydrological cycles, in particular, over the period of 2012–2019, several forestry stations faced a sharp waterlogging of forests (the formation of soaks) over a large area (in some forestry stations, the value reached 15 %). This is due to a change in the depth of groundwater and the plowing of the edge of the forest, which contributed to the disruption of the natural watercourse.

In this regard, the applicability of such an integrated approach is limited to areas where forest management standards are not violated. Otherwise, the long-term forecasts are significantly compromised.

The practical implementation of an integrated approach to the restoration and increase of the total area of forest land significantly improves the efficiency of work carried out, but, at the same time, imposes restrictions on planting in certain zones of regulated crops. For example, in modern forest management, birch and pine are chosen as the main ones for sowing crops. However, in the studies, over approximately 30 % of the area, our soil analysis showed the need for primary planting of elm (or other breeds that contribute to soil salting), while earlier attempts to plant the main crops led to financial losses. Building on the method of integrated ecological and geographical research could in the future significantly improve the efficiency of forest management work in general and minimize losses associated with environmental influences.

7. Conclusions

1. During our work, reconnaissance was carried out by the method of route survey of sites; the following was studied on the ground:

– the characteristics of the relief of the sites;
– the types of vegetation;
– taking soil samples;
– the description of the soil structure of the plots according to the field study of the soil section;
– the types of plant associations have been highlighted;
– the following types of plant associations were identified at the surveyed sites: in the Kamysh forestry station, 3 types of plant associations were identified in the surveyed areas, but two types of soils – slightly solonetzic chernozem (two differences differing in the content of dissolved salts) and medium solonetzic sulfate-magnesium solonetz. In the Burluk forestry station, 3 plant associations and, accordingly, 3 types of soils were identified in the surveyed areas: slightly solonetzic chernozem, medium solonetzic chernozem, southern medium solonetzic chernozem on a rock base. In the Nagorny forestry station, 1 type of plant association and soil was identified in the surveyed areas: common chernozem.

2. According to the structure and chemical analysis, the soil type of the first site considered is slightly solonetzic chernozem. Suitable for all major forest-forming species. For the plot in allotment 62, block 1, according to the structure and chemical analysis, the type of soil is slightly solonetzic chernozem. Suitable for all major forest-forming species. For section No. 3, laid down in block 3, allotment 58, according to the structure and chemical analysis, the soil type is medium solonetzic sulfate-magnesium solonetz (3.8 hectares). It is unsuitable for the main forest-forming species of the region. For the section laid down in allotment 1, block 2, based on the structure and chemical analysis, the soil type is slightly solonetzic chernozem. Suitable for all major forest-forming species. According to the structure of the section laid down in allotment 6, quarter 11, and based on the chemical analysis, the soil type is medium solonetzic chernozem. Suitable for all major forest-forming species. For section No. 8, laid down in block 7, allotment 6, the soil type, according to the structure and chemical analysis, is southern medium-saline chernozem on a rock base. Suitable for all major forest-forming species. The light mechanical composition of the entire soil profile allows us to recommend the site for planting coniferous species. According to the structure and chemical analysis, the type of soil of the section laid down in allocation 21, quarter 14, is common chernozem. Suitable for all major forest-forming species.

3. We have devised recommendations for afforestation activities: the area of plots suitable for all major forest species in the Kamysh forestry is 182.2 hectares; in the Burluk forestry station, 109.2 hectares; and 61.5 hectares in the Nagorny forestry station; the area of plots with existing forests/forest crops/overgrown with self-sowing in the Kamysh forestry station is 10.2 hectares; in the Burluk forestry station, amounted to 21.8 hectares; in the Nagorny forestry station, 16.8 hectares.

References

1. Belov, A. V., Sokolova, L. P. (2009). The socio-economic role of vegetation in the cartographic substantiation of rational management of nature in the geobotanical forecasting system. Geography and Natural Resources, 30 (2), 119–125. doi: https://doi.org/10.1016/j.gnr.2009.06.005
2. Rubtsov, M. V. (1984). A classification of the function and role of forest. Lesovedenie, 2, 3–9.
3. Belov, A., Sokolova, L. (2008). Vegetation stability in the system of geobotanical forecasting. Geography and Natural Resources, 29 (2), 124–131. doi: https://doi.org/10.1016/j.gnr.2008.06.016
4. Sochava, V. B. (1978). An Introduction to the Theory of Geosystems. Novosibirsk: Nauka, 319.
5. Sochava, V. B. (1979). Vegetation on Thematic Maps. Novosibirsk: Nauka, 188.

6.   Soudek, P., Petřík, P., Vágner, M., Tykva, R., Plojhar, V., Petrová, Š., Vaněk, T. (2007). Botanical survey and screening of plant species which accumulate 226Ra from contaminated soil of uranium waste depot. European Journal of Soil Biology, 43 (4), 251–261. doi: https://doi.org/10.1016/j.ejsobi.2007.02.008

7.   Semenkov, I., Konyushkova, M., Heidari, A., Nukhimovskaya, Y., Klink, G. (2020). Data on the soilscape and vegetation properties at the key site in the NW Caspian sea coast, Russia. Data in Brief, 31, 105972. doi: https://doi.org/10.1016/j.dib.2020.105972

8.   Kozyr, I. V. (2014). Forest Vegetation Dynamics Along an Altitudinal Gradient in Relation to the Climate Change in Southern Transbaikalia, Russia. Achievements in the Life Sciences, 8 (1), 23–28. doi: https://doi.org/10.1016/j.als.2014.11.006

9.   Goncharova, O., Matyshak, G., Udovenko, M., Semenyuk, O., Epstein, H., Bobrik, A. (2020). Temporal dynamics, drivers, and components of soil respiration in urban forest ecosystems. CATENA, 185, 104299. doi: https://doi.org/10.1016/j.catena.2019.104299

10. Belov, A. V., Sokolova, L. P. (2017). Geobotanical forecasting in the nature management ecological optimization in Baikalian Siberia. Geography and Natural Resources, 38 (1), 38–45. doi: https://doi.org/10.1134/s187537281701005x

11. Gongalsky, K. B., Iurmanov, A. A., Ukhova, N. L., Korobushkin, D. I. (2020). The size of burnt areas has little effect on the recovery of soil macrofauna in the boreal forests of Middle Ural, Russia. Pedosphere, 30 (5), 714–718. doi: https://doi.org/10.1016/s1002-0160(20)60032-7

12. Belov, A. V., Sokolova, L. P. (2009). Functional organization of vegetation in the system of cartographic forecasting. Geography and Natural Resources, 30 (1), 8–13. doi: https://doi.org/10.1016/j.gnr.2009.03.003