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RESEARCH ARTICLE

Recommendations for Sustainable Greening of Urbanized Ecosystems in Dry-Steppe Zones of Akmola Region, Kazakhstan

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ABSTRACT

The research investigates woody species vegetation of roadside greenery of Nur-Sultan/Karaganda (24 woody plants) and Nur-Sultan/Borovoye highways (16 woody plants). According to the species composition, more than 70% of woody vegetation are dust, gas, and drought resistant, and about 60% are salt tolerant. From 18 woody species planted on research plot of the university campus, 58% of the woody plants have taken root. Likewise, in 2 species, a high survival rate of more than 85% was observed (*Acer negundo* L. with 96.5% and *Ulmus pumila* cv. jinye with 85.5%); in 7 species – satisfactory survival rate of 25-85% (*Pinus sylvestris* with 79.4%; *Syringa oblata* Lindl with 76%; *S. pubescens* Turcz. with 74%; *Ulmus laevis* Pall. with 65.5%; *Amorpha fruticosa* Linn with 63.5%; *Elaeagnus angustifolia* L. with 62.5%; *Malus* 'Royalty' with 39.5%); in 5 species – low survival rate of less than 25% (*Catalpa ovata* G.Don. with 17.5%; *Salix myrsinifolia* Salibs. with 16.5%; *Fraxinus americana* L. with 15.5%; *Syringa reticulata* (Blume) H. Hara with 14.5%; *Amygdalus triloba* (Lindl) Ricker with 10.5%); 4 species have no survival (*Fraxinus bungeana* A.DC., *Populus euphratica* Oliv., *Haloxylon persicum* Bunge, *Tamarix laxa* (Willd.). The soils of roadsides of Nur-Sultan/Karaganda, Nur-Sultan/Borovoye motorways showed very low and low levels of humus (<4%) and easily hydrolyzed nitrogen (<30mg/kg), characterized by significant variability of mobile P. The roadsides of Nur-Sultan/Karaganda and Nur-Sultan/Borovoye highways are characterized by an average and high content of exchange K, and weak salt content (from 0.04% to 0.17%). The salinity chemistry is sulfate-bicarbonate. Nur-Sultan/Borovoye highway is characterized from mild to very strong sulfate and chloride salinization (from 0.15% to 0.85%). The amount of toxic salts is 23.20%. As a result, in order to optimize the sustainable ecological conditions of landscape and intercity systems in urbanized areas in dry-steppe regions, more effectively, it is highly recommended to use woody species with high survival percentage and growth performance.

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Introduction

Kazakhstan extends from the downstream of the Volga River in the west to the Altai Mountains in the east and from the Zailiyskiy Alatau Mountains of the Northern Tien Shan in the south to the West Siberian Lowland in the north.

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The total area is 272.5 million hectares, including forest-steppe, steppe, semi-desert and desert zones. Kazakhstan is the 9th country in the world by the area of its territory (Anonymous, 2018).

In modern conditions, the deterioration of the state of natural resources and the environment for all the most important environmental indicators is becoming a serious problem. A significant part of Kazakhstan territory is at increased risk of environmental destabilization. The problem of desertification is acute. The causes of desertification in Kazakhstan are both natural and anthropogenic factors (Sarsekova et al., 2016). The main natural factors contributing to the development of desertification processes are the country's intercontinental position, which determines the aridity of the climate, the scarcity and uneven distribution of water resources, the wide distribution of sand (up to 30 million hectares) and salinity of the land (127 million hectares) (Sarsekova et al., 2015). A prerequisite for desertification is also the poor formation of the soil and vegetation cover and its dynamism. These natural factors determine the weak resistance of the natural environment to anthropogenic influence. Today, about 75% of the country's territory is at increased risk of environmental destabilization (Sarsekova et al., 2016).

Kazakhstan belongs to the least forested areas in the world. In all five states of the region of Central Asia - Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan – forests cover less than 10% of the territory (FAO, 2007; 2010). However, national changes in forest areas over the past 25 years (1990-2015) showed positive trend for Kazakhstan and Kyrgyzstan and negative trends for Uzbekistan (Sakıcı and Ayan, 2016).

One of the most difficult environmental problems of Kazakhstan is the Aral Sea region – a zone of intense desertification, salinization and deflation. Recent studies of the Kazakh Research Institute of Soil Science and Agro chemistry show that anthropogenic aridization and soil transformation in the Aral Sea region continues (Semenov, 2012; Issanova et al., 2013; 2015). The removal of the sand-salt aerosol from the Aral Sea region in the eastern direction reaches 150-200 km, and in the western direction, the extension plume extends 700 km towards the Caspian Sea. An equally important problem in Kazakhstan is the impact of the activities of the Baikonur Spaceport on the country's ecosystem. In this regard, the creation and expansion of green areas of natural territories is the most effective way to ensure the conservation of valuable natural complexes, biodiversity, restoration and improvement of the biological potential of the natural environment (Anonymous, 2003b; 2007a; 2007b).

The Republic of Kazakhstan belongs to the states with small areas under forests. Only 4.7% of the territory is covered by forests, including saxaul (*Haloxylon* spp.: Black saxaul, *H. aphyllum* (Minkw.), White saxaul, *H. persicum* Bunge) plantations, which account for almost half of the forested area. Nevertheless, despite their small size, the forests play an important role in soil protection, climate and water regulation, water protection and recreation (Yesserkepova, 2010; Mambetov et al., 2013; Sarsekova et al., 2016). Currently, as a result of human impact it was identified that saxaul is spread only on 25% of potential areal in Kazakhstan. About three thirds of potential area of saxaul forests were destroyed or they deteriorated comparing to potential areal (Aleksandrovna Zhaglovskaya et al., 2016). The main part of the mountain forests is represented by dark coniferous plantations of Altay, Dzhungarskiy and Zailiyskiy Alatau. Saxaul forests grow in the desert zone (*Haloxylon ammodendron, H. persicum, H. aphyllum)*. Due to the variety of natural conditions, various types of forests are found on the territory of the Republic: birch–spruce forests, pine–spruce and ribbon forests, mountain forests, floodplain and tugai forests as well as saxaul forests (Anonymous, 2018). Forests of the Republic carry out important climate control, environment-forming, field and soil protection, water protection and sanitary-hygienic functions. The sharply continental climate prevailing in most of the Republic leads to harsh forest growing conditions that impede forest reproduction and afforestation (Anonymous, 2019).

Extensive experience in protective afforestation has gained in the Republic. However, at present, protective forest belts are in crisis due to the absence of a provision on their status. Significant stripes of forest shelterbelts were cut down and withered (Anonymous, 2018). It was ceased laying experience of new protective afforestation. Forest areas has an important role in the environmental protection of the territory, therefore, given the low forest cover of the territory in Kazakhstan as a whole; primarily, all forests in the country are assigned to the forests as the 1st group, which perform mainly water protection, protective, sanitary-hygienic and recreational functions (Anonymous, 2003a). The only region where new forest plantations are being established in recent years is the capital of Kazakhstan, Nur-Sultan (Anonymous, 2006; 2018).

Nur-Sultan is located in the Akmola region of Central Kazakhstan. The Yesil River is the only waterway in the capital with two small inflows, Sarybulak and Akbulak. The climate is sharply continental, arid, with hot summers, cold winters and fitful winds. As of January 1, 2019, the land cover of the Akmola region is 146,200 square kilometers, while the share of specially protected natural areas is 3.6%; the share of the forest fund is 3.6%. The forest cover of the region is 2.6% (Anonymous, 2018). There are the Korgalzhyn State Nature Reserve of international importance, 3 state national natural parks (Burabay, Buiratau, Kokshetau), 3 state natural zoological reserves (Atbasarskiy, Bulandynskiy, Vostochniy), and 8 state nature monuments located in the Akmola region (Anonymous, 2018; URL1, 2020).

Nur Sultan is one of the fastest growing megacities in the whole Eurasian space. The territory of the city is 810,2 km^2, of which natural and recreational areas are 34770 ha, including parks, squares, boulevards with 4900 ha, and natural landscape areas with 29870 thousand ha. The population as of January 1, 2020 amounted to 1 136 156 people (URL2, 2020). According to the "*Master Plan for the Development of the City of Astana until 2030*" and the "*Concept of Gardening the City of Astana for 2007-2030*", the authorities planned landscaping of the city territory, access roads, suburban and residential areas of the region. In order to improve the ecosystem of the city, it is planned to create large green areas and a system of green corridors along rivers that will serve as a link between parks and suburban natural areas. To date, the landscaping area of urban areas is 15 thousand hectares. During the implementation of these measures, it is planned to increase the portion of green areas to 52% (Anonymous, 2004; 2006).

In connection with the adverse climatic conditions of the region, since 1997 a large-scale campaign has been carried out to create a protective "Green Belt" around the city of Nur Sultan. Today, the total area of the "Green Belt" is about 14 827 hectares, with the actual area of forests of about 11 502.2 ha, where more than 9.6 million trees and about 1.8 million shrubs grow. The share of broadleaves is 98.2%, conifers 1.8% (URL3, 2020). As part of this project, it is planned to connect the "Green Belt" with the Shchuchinsk-Borovoy resort area and the Alakol State Nature Reserve. The current intercity system of the landscaping of the Nur-Sultan, both in area and in terms of environmental and sanitary-hygienic functions, does not meet the needs of the metropolis (Anonymous, 2006).

The study was prepared based on the results of the research work "*Landscape-ecological assessment of the state of green spaces of the city of Astana and suburban areas, ways to optimize the landscaping system*" carried out under budget program 217 Development of the science "Grant funding for scientific research for 2018-2020".

Materials and Methods

In order to conduct a landscape-ecological assessment of the roadside greenery motorways of the Nur-Sultan city, two main highways were selected: The Nur-Sultan-Karaganda and the Nur-Sultan-Borovoye highway (Figure 1, 2).

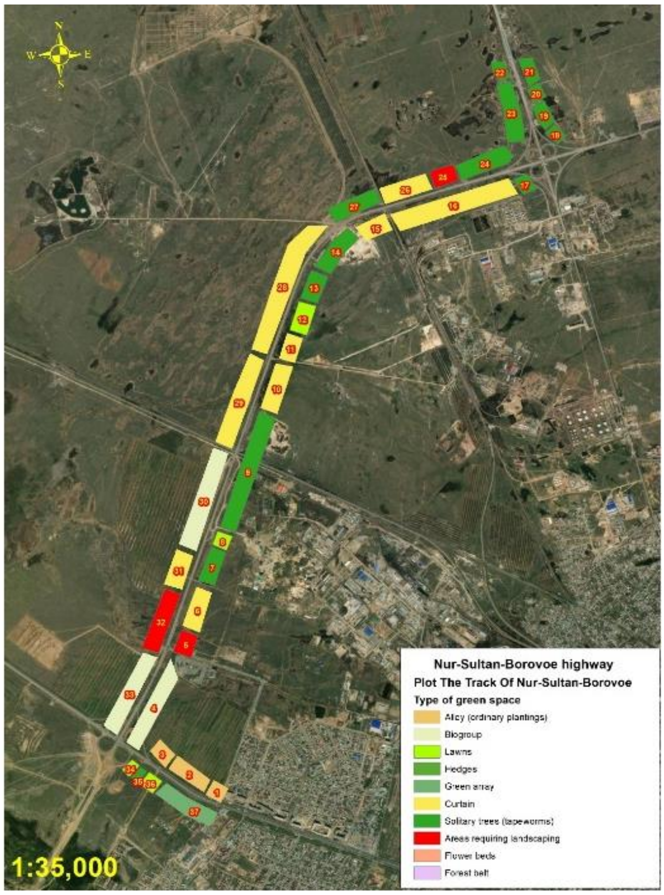

Figure 1. Taxation map of the Nur-Sultan-Borovoe route in the ArcGIS Desktop 10.8 program

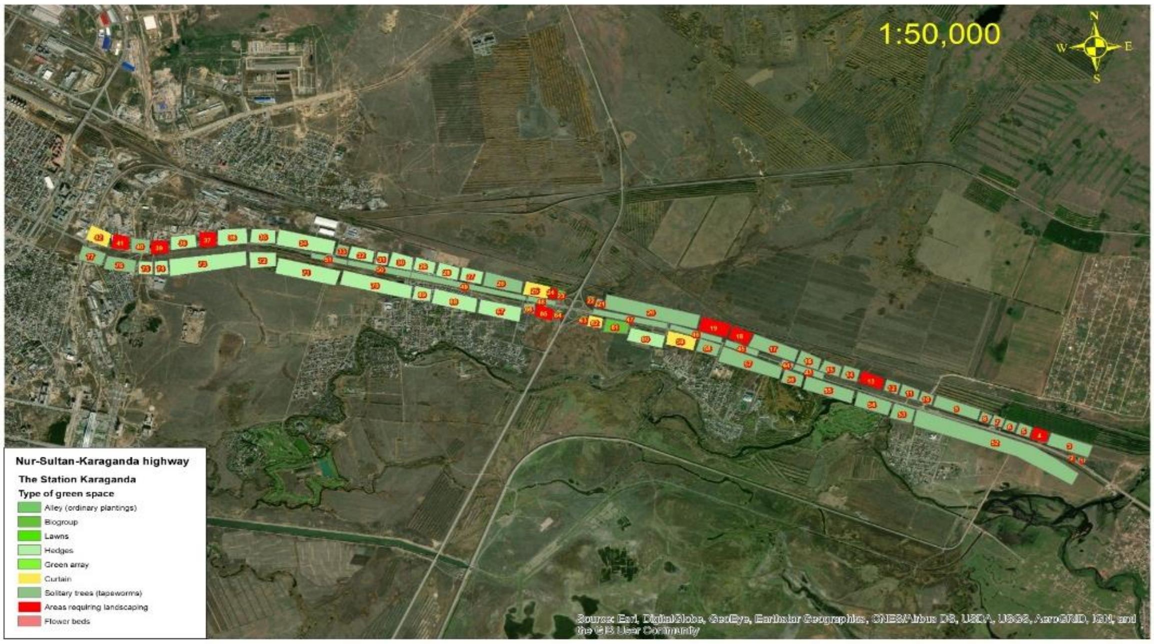

Figure 2. Taxation map of the Nur-Sultan-Karaganda highway in ArcGIS Desktop10.8 program

To study the woody vegetation of the roadside strips of the route, a section of the route with a length of more than 30 km was determined, which was divided into 77 subsections. During the landscape-ecological assessment of the Nur-Sultan-Karaganda highway, various types of landscape and types of green spaces were identified: Green spaces, groves, curtains, bio-groups, alleys, single trees, hedges, lawns, swamps, ravines and vacant lots (Figure 3, 4, 5, 6). In fact, the roadside greenery of the Nur-Sultan/Karaganda highway has a length of 30.855 km, of which the alley plantings of tree-shrub vegetation are 930 m, group plantings – 13,030 m, open forest – 3,525 m, curtains – 3,845 m., agricultural land – 510 m, bio-groups – 430 m, marshes – 1,350 m, ravines – 470 m, ordinary plantings of squat elm (*Ulmus pumila* L.) – 5,635 m, and vacant lots – 1,130 m. The main share in the landscaping of roadside territories is made by group planting of trees and shrubs with 42.2%; ordinary plantings of squat elm with 18.3%; curtains with 12.5% and open forests with 11.4%.

Figure 3. Field work on the Nur-Sultan-Karaganda highway

Figure 4. Swamps along the Nur-Sultan-Karaganda highway

Figure 5. Row planting of trees and shrubs along the Nur-Sultan-Karaganda highwa

Figure 6. Ravines and open spaces along the Nur-Sultan-Borovoe highway

An inventory of the woody plants vegetation of the highways was carried out according to Sarsekova (2014), using map schemes on a scale of M = 1:500. According to the methodology, the species, age and quantitative composition of tree-shrubby vegetation, their condition, height, openwork of the crown of trees, the presence of pests, and recommendations on economic activities were determined (These data are not presented in this paper). The height of trees and shrubs was determined using a Suunto PM-5/1520 altimeter; the area of lawns were determined using a Leica DistroD5 laser range finder. Inventory data was entered into taxation logs and assortment lists. Based on the results of the inventory, electronic maps of green spaces were compiled in the ArcGIS Desktop 10.8 program.

To determine the soil sampling points, the technologies of the global positioning system (GPS) and geographic information systems (GIS) were used. Soil sampling was carried out with a drill at points tied to coordinate systems using GPS receivers. Soil samples were taken by a soil drill from a depth of 0-30 cm according to the method GOST 17.4.4.02-84 (2008). Sample weight is 400-500 g. Soil preparation was carried out in accordance with the method GOST 29269-91 (1992a). During chemical analyses of the soils, classical methods were used: determination of humus according to I.V. Tyurin' method GOST 26213-91 (1992b), determination of readily hydrolysable nitrogen according to I.V. Tyurina-Kononova's method GOST 26951-86 (1986) determination of mobile phosphorus according to B.P. Machigin's method GOST 26205-91 (1992c), exchange potassium - on a flame photometer GOST 26205-91 (1992c), analysis of water extraction for salinity according to K.K. Gedroits's method GOST 27753.4-88 (1989) at the accredited laboratory of S. Seifullin Kazakh Agrotechnical University.

Whether there was a difference between the survival percentages of tree species in 2018 and 2019 was determined by variance analysis and Newman Keulls multiple tests were applied to determine homogeneous groups. Forest crops with survival rates of less than 25% are considered unsatisfactory, crops with survival rates of 25% to 85% of the normative are satisfactory; above 85% of survival rates are well established.

Results and Discussion

The main objectives of landscaping the operated roads and their structural elements are to protect the roads from the effects of adverse weather and climate factors, to protect the territories adjacent to the road from traffic pollution, to create elements for the improvement and architectural artistic design of the road, as well as to provide visual orientation for drivers (Neverova and Kolmogorova, 2003). The creation and maintenance of favorable and comfortable conditions for users of highways and residents adjacent to the road territories serve as a common goal of all these tasks (Anonymous, 1998).

In Nur-Sultan/Karaganda highway, the assortment of tree and shrub species in the ordinary plantings of the protective bands is represented by 24 species: *Populus alba* L., *P. balsamifera* L., *Ulmus pumila* cv. *jinye*, *U. glabra* (Ach) Vain., *Acer negundo* L., *A. tataricum* Rostr., *Malus baccata* (L.) Monech, *Picea abies* (L.) H. Karst., *Pinus sylvestris* L., *Elaeagnus angustifolia* L., *E. commutata* Bernh. ex Rydb., *Prunus padus* L., *Crataegus laevigata* DC., *Betula pendula* Roth, *Salix viminalis* L., *S. alba* L., *S. fragilis* L., *Fraxinus excelsior* L., *Lonicera tatarica* L., *Rosa canina* L., *Prunus dulcis* (Mill.) D.A. Webb, *Hippophae rhamnoides* L., *Caragana arborescens* Lam. and *Ribes aureum* Pursh. At the same time, 91.3% of the species are broadleaf and 8.7% are coniferous.

The main deciduous species are *Ulmus pumila*, *Populus balsamifera*, *P. alba*, *Caragana arborescens*, *Acer negundo*, *A. tataricum*, *Elaeagnus angustifolia* and others. Hedges are formed from *Ulmus pumila*, *Caragana arborescens*, *Lonicera tatarica* and *Acer tataricum*.

The Nur-Sultan-Borovoye highway is a republican high-speed highway. The total length of the surveyed roadside strips was 20.4 km for The Nur-Sultan-Borovoye highway. According to the type of greenery, green areas, curtinas, bio-groups, alleys, single trees, hedges, backstage, vacant lots, swamps are defined. By age, trees are mostly older than 30 years. The area occupied by green spaces (alleys, bio-groups, curtains) is 61.3%; the proportion of single trees is 31.6%; areas requiring landscaping (wasteland, sparse) 7.1%. The length of hedges and wings is 1,030 linear meters.

In Nur-Sultan/Borovoye highway; The species composition of woody vegetation along the route is represented by 16 species: *Populus alba, P. balsamifera, Ulmus pumila, Acer negundo, A. tataricum, Malus baccata, Pinus sylvestris, Larix sibirica* Ledeb., *Elaeagnus angustifolia, E. commutata*, *Betula pendula, Salix viminalis, S. alba, Lonicera tatarica, Caragana arborescens,* and *Ribes aureum*. The share of conifers is 12.5%, broadleaves 87.5%. The total length of hedges from *Caragana arborescens* is 240 linear m, *Ribes aureum* 250 linear m and *Ulmus pumila* with 200 linear m.

The following environmental and economic measures are recommended for the Nur-Sultan-Karaganda, Nur-Sultan-Borovoe highways: pruning of dry branches; processing frost cracks on tree trunks; phytosanitary treatment against pests; reconstruction of thinned landings; erosion control, snow and sand protection, noise, gas and dust resistant landscaping in roadside areas deprived of tree-shrubby vegetation, open spaces; biological reclamation of ravines, swamps and lowlands; the organization of sanitary protection zones at gas stations.

As follows from the literature data, according to the species composition, over 70% of woody vegetation are dust, gas, drought resistant and about 60% are salt tolerant (Nikolaevskij, 1980; Smirnov, 1986; Kosulina et al., 1993; Neverova and Kolmogorova, 2003).

The main factors determining the state of green spaces is soil fertility, which, in turn, depends on the content of biophilic elements available to plants, mainly such as N, P, and K compounds (Mineev, 2004; Kurbatova, 2004). The soil of the city of Nur-Sultan is part of the Esil-Nurinskiy sub-province and is composed of dark chestnut, meadow chestnut, floodplain, meadow bog, chestnut, bog chestnut, alkali soil, saline and urbanozems (Klebanovich et al., 2016). According to the results of agrochemical studies, the roadside of the Nur-Sultan-Karaganda highway are characterized by a very low content of easily hydrolysable nitrogen (<30 mg/kg). The roadside territories of the Nur-Sultan-Borovoye highway are also characterized by a very low content of easily hydrolysable nitrogen (<30 mg/kg): the nitrogen concentration ranges from less than 2 to 44.7 mg/kg (Table 1). Thus, the results of agrochemical studies of soil samples of roadside territories of inbound motorways of the city of Nur-Sultan and the suburban zone showed a very low content of easily hydrolysable nitrogen, which indicates an acute deficit of N nutrition.

Table 1. Analysis of soil samples of roadside strips of inbound motorways of the city of Nur-Sultan

Object name	**Sample №**	**Depth of soil samples (cm)**	**Content of humus** (%)	**Easily hydrolysable nitrogen (mg/kg)**	**Mobile P (mg/kg)**	**Exchange K (mg/kg)**
Nur-Sultan-Karaganda highway	1	0-30	1.54	20	42.57	550
	2		2.28	less than 2	22.6	466
	3		1.08	3.1	20.68	346
	4		0.50	less than 2	58.92	248
	5		0.73	less than 2	49.3	246
	6		1.22	less than 2	16.35	852
	7		6.06	less than 2	124.11	314
Nur-Sultan - Borovoye highway	1		1.03	24.6	11.3	334
	2		0.30	5.2	18.76	364
	3		1.00	3.4	34.63	210
	4		1.56	less than 2	17.31	1320
	5		1.38	28.8	33.67	250
	6		1.13	44.7	26.45	280
	7		2.29	4.4	27.42	624

The next important macro element in the soil is P. As it is seen from Table 1, in the soil images of roadside territories of the Nur-Sultan/Karaganda highway, low P content is noted at points No. 2, 3, 6 and varies between 16.35-22.60 mg/kg of soil. The increased P content is noted at point No. 1 - 42.57 mg/kg and the high P content at points No. 4, 5, 7 and fluctuates in the range of 49.30-124.11 mg/kg. That is, the variability of the content of mobile P is quite high. Thus, part of the surveyed sections of the Nur-Sultan/Karaganda route has a low P content, and part of the sections have an increased and high degree of provision with mobile P. The results of the analysis of soil images of the roadside territories of the Nur-Sultan/Borovoye highway showed that at points 1, 2, 4 there is a very low and low content of mobile P - 11.3-18.76 mg/kg of soil. At points No. 3, 5-7, the average content of mobile P is noted and amounted to 26.45-34.63 mg/kg. Thus, soil samples of the roadside territories of the Nur-Sultan/Karaganda highway are characterized by low, high and high levels of mobile P, and the Nur-Sultan/Borovoye highway by low and medium levels of mobile P. The reasons for the lack of P in the soil are probably associated with poor soil microflora and the transition of P to hard-to-reach compounds. In this connection, in autumn, phosphorus fertilizers must be applied in some places for digging the soil.

Potassium is an essential element of soil nutrition of plants. As follows from the data in Table 1, soil samples of roadside territories of the Nur-Sultan/Karaganda highway have an average content of exchange K at points No. 4 and 5 (246-248 mg/kg); increased - at points No. 3 and 7 - 314-346 mg/kg; high at points No. 1, 2 - 466-550 mg/kg and very high - at point No. 6 - 852 mg/kg. As follows from the data in table 1, soil samples of roadside territories of the Nur-Sultan/Borovoye highway have an average content of exchange K at points No. 3, 5, 6 (210-280 mg/kg); increased - at points No. 1, 2 - 334-364 mg/kg and very high - at points No. 4 and 7 - 624-1320 mg/kg of soil. Thus, agrochemical studies of soil samples along the routes of the city of Nur-Sultan showed that the roadside territories of the Nur-

Sultan/Karaganda and Nur-Sultan/Borovoye highways are characterized by an average and high content of exchange K, and the campus has a high and very high metabolic K content. On highways in places with a deficiency of K nutrition of plants, the introduction of potash fertilizers is required.

According to analysis of soil samples taken on the roadside territories of the Nur-Sultan highways, it follows that the humus content along the Nur-Sultan/Karaganda highway varies between 0.50 - 6.06%: at points 1, 3-6 it is very low humus content; at point No. 2 - low humus content; at point 7, the average humus content. In the roadside territories of the Nur-Sultan/Borovoe highway, the concentration of humus is in the range of 0.30-2.29%, which also indicates very low humus content. Thus, soil samples taken on the roadside territories of the Nur-Sultan/Karaganda, Nur-Sultan/Borovoe highway are characterized by very low humus content. The miserable humus content indicates unfavorable conditions for the formation of the humus horizon and low soil fertility, which is due to the small accumulation of plant biomass and the destruction of humic humus compounds. To increase the humus content, it is recommended to introduce organic fertilizers, carry out phytomelioration and increase the number of forest stands.

To determine the salinity of the soil, we determined the concentrations of hydrocarbon ions ($Ca(HCO_3)_2$, $Mg(HCO_3)_2$, $NaHCO_3$), sulfate ions ($CaSO_4$, Na_2SO_4, $MgSO_4$), chloride ions ($NaCl$, $MgCl_2$, $CaCl_2$), nitrate-ions ($Mg(NO_3)_2$, $NaNO_3$), pH, sum of cations, percentage of salts, solubility of salts, amount of toxic salts and type of salinization. According to the results of studies, it follows that in the section of the Nur-Sultan-Karaganda highway, at the survey points, a weak salt content is observed from 0.04% to 0.17%. The salinity chemistry is sulfate-bicarbonate. The data of the Nur-Sultan-Borovoye section of the highway showed that from the soil there is from low to very strong sulfate and chloride salinity - from 0.15% to 0.85% at points No. 2, 5, 6. At point No. 3, sulfate is observed salinity is 14.47% and chloride at point No. 3, where the chloride ion content is 6.83%. The amount of toxic salts is 23.20%. In terms of chemical composition, chloride-carbonate salinization ($NaHCO_3$, Na_2CO_3) is the most harmful to plant organisms. The least dangerous for crops is the accumulation of sulfate salts ($CaSO_4$, $MgSO_4$). An intermediate position in terms of the degree of toxicity to plants is occupied by chloride-sulfate salinization ($MgCl_2$, $NaCl$, Na_2SO_4). pH of the soil samples taken on the roadside territories of the Nur-Sultan/Karaganda highway ranges from 6.95-8.15; Nur-Sultan/Borovoe highway - 6.65-8.42; campus - 7.5-8.08, i.e., pH of the medium varies from neutral to slightly alkaline, which is a favorable soil condition for the growth of trees and shrubs.

In order to expand the assortment of green spaces of the city of Nur-Sultan and suburban areas, in the rural district of Kabanbay Batyr of Akmola region, on the territory of the scientific and experimental campus of S. Seifullin Kazakh Agrotechnical University since 2017 on an area of 1.8 hectares, the survival of salt-tolerant and drought-resistant species of trees and shrubs imported from the People's Republic of China and the south of Kazakhstan has been investigated. In addition, to compare survival in extreme environmental conditions, local breeds were planted.

On the scientific and practical campus, 18 species of trees and shrubs were planted, i.e., *Catalpa ovata*, *Salix myrsinifolia*, *Syringa pubescens* Turcz., *Fraxinus americana* L, *Ulmus pumila*, *Amorpha fruticosa* Linn., *Syringa oblata* Lindl., *Ulmus laevis*, *Acer negundo*, *Fraxinus bungeana* A.DC., *Populus euphratica* Oliv., *Syringa reticulata* (Blume) H. Hara, *Amygdalus triloba* (Lindl) Ricker, *Elaeagnus angustifolia*, *Haloxylon persicum* Bunge, *Tamarix laxa* Willd., *Malus* 'Royalty' and *Pinus sylvestris* (Table 2). According to the results of the variance analysis of the survival rate data in 2018 and 2019, the tree and shrubs species made a significant difference in the survival percentage statistically. It can be noted that many of the tested species have taken root quite well.

Table 2. The survival rate of the trees and shrubs on the scientific and experimental campus

№	Scientific name	Number of planted specimens	Census (individuals)		Survival (%)	
			2018	2019	2018	2019
1	*Catalpa ovata* G. Don.	200	151	35	75.5±0,17 ı	17.5±0,17 ı
2	*Malus* 'Royalty'	150	110	59	73.3±0,11 j	39.5±0,17 i
3	*Salix myrsinifolia* Salisb.	200	190	33	95±0,11 c	16.5±0,05j
4	*Syringa microphylla* Diels	200	183	148	91.5±0,23 e	74.0±0,11 e
5	*Fraxinus americana* L.	200	174	31	87±0,11 h	15.5±0,05 k
6	*Ulmus pumila* cv. *jinye*	200	183	171	91.5±0,05 e	85.5±0,12 b
7	*Amorpha fruticosa* Linn	200	178	127	89±0,17 g	63.5±0,17 g
8	*Syringa oblata* Lindl.	200	181	152	90.5±0,11 f	76.0±0,17 d
9	*Ulmus laevis* Pall.	200	192	131	96±0,34 b	65.5±0,01 f
10	*Acer negundo* L.	200	-	193	100±0 a	96.5±0,05 a
11	*Fraxinus bungeana* DC.	200	188	-	94±0,05 d	0 n
12	*Populus euphratica* Oliv.	200	181	-	90.5±0,11 f	0 n
13	*Haloxylon persicum* Bunge	200	43	-	21.5±0,05 l	0 n
14	*Syringa reticulata* (Blume) H.Hara	200	164	29	82±0,17 l	14.5±0,05 l
15	*Tamarix laxa* Willd.	200	137	-	68.5±0,11 k	0 n
16	*Amygdalus triloba* (Lindl.) Ricker	200	90	21	45±0,51 l	10.50,17 m
17	*Pinus sylvestris* L.	200	43	1191	100±0 a	79.4±0,11 c
18	*Elaeagnus angustifolia* L.	200	125	125	100±0 a	62.5±0,11 h
P values					0,000 ***	0,000 ***

When taking into account the survival rate of woody plants in 2019, it was revealed that out of 4,450 planted tree and shrubbery species, 2,446 took root, which is 58%. As shown in Table 2, *Acer negundo* (96.5%) and *Ulmus pumila* (85.5%) are the most resistant to alkaline and saline soils. *Pinus sylvestris* (79.4%), *Syringa oblata* (76%), *S. pubescens* (74%), *Ulmus laevis* Pall. (65.5%), *Amorpha fruticosa* (63. 5%), *Elaeagnus angustifolia* L. (62.5%), *Malus* 'Royalty' (39,5%) showed satisfactory survival rate. These woody species have achieved high growth rates. The survival rate is less than 25%, i.e., *Catalpa ovata* showed unsatisfactory (17.5%), *Salix myrsinifolia* (16.5%), *Fraxinus americana* (15.5%), *Syringa reticulata* (14.5%), *Amygdalus triloba* (10.5%). In fact, these tree and shrub species poorly adapted to the climatic conditions of the region and salinity of the soil. Zero survival rates were demonstrated by *Fraxinus bungeana*, *Populus euphratica*, *Haloxylon persicum*, *Tamarix laxa*, i.e., they did not adapt to the climatic and soil conditions of this region (Figure 7).

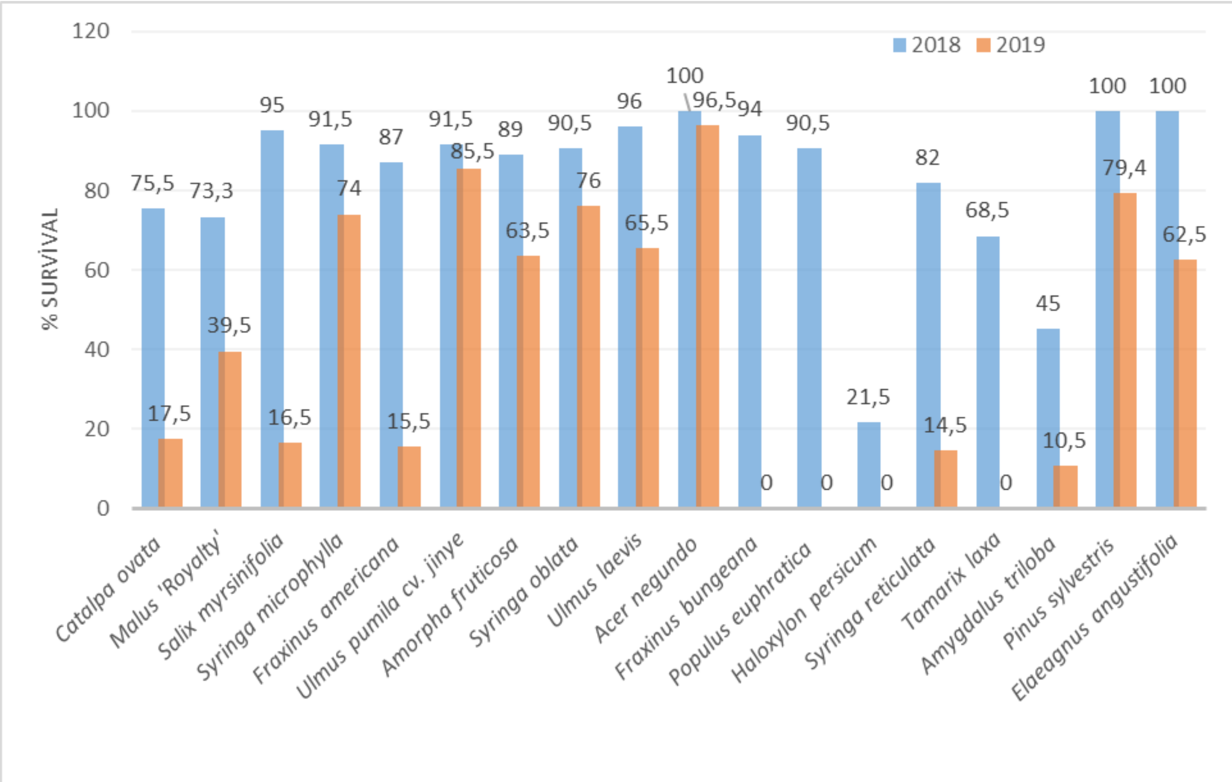

Figure 7. The survival rate of the woody vegetation (%)

Conclusion

During the research of the the roadside greenery of the Nur-Sultan/Karaganda and the Nur-Sultan-Borovoye highways, various types of landscape and types of green spaces were investigated: green areas, groves, curtains, bio-groups, alleys, solitary trees, hedges, lawns, swamps, ravines, vacant lots. The species composition of woody vegetation along the Nur-Sultan/Karaganda highway is represented by 24 species, along the Nur-Sultan/Borovoye highway 16 species. A low proportion of conifers and shrubs are noted 8.6-12.5%. Of the tree-shrub species growing on the Nur-Sultan/Karaganda and Nur-Sultan/Borovoye highways, only 4 species are native: *Pinus sylvestris*, *Betula pendula*, *Lonicera tatarica*, *Rosa canina*.

Determination of environmental factors in the soil of the roadside territories of the inbound motorways Nur-Sultan/Karaganda, Nur-Sultan/Borovoye showed a very low and low content of humus (<4%) and easily hydrolyzed N (<30 mg/kg), which requires the introduction of nitrogen fertilizers and humus for normal growth of trees and shrubs. The soils of the investigated areas are characterized by significant variability of mobile P in the soil - from 16.35 to 124.11 mg/kg, i.e., the roadside territories of the Nur-Sultan/Karaganda highway are characterized by low, high levels of mobile P, and the Nur-Sultan/Borovoye highway has low and medium levels of mobile P. In correlation, in autumn, phosphorus fertilizers should be applied to a depth of about 10 cm of the soil but not scattering on the soil surface. Agrochemical studies of soil samples along the highways of the city of Nur-Sultan showed that the roadside territories of the Nur-Sultan/Karaganda highway are characterized by an average and high content of exchange K, the Nur-Sultan/Borovoye highway is characterized by an average and high content of exchange K, and the campus has high and very high content exchange K. On highways in places with a deficiency of potassium nutrition of plants, the introduction of potash fertilizers is required.

In the roadside territories of the Nur-Sultan/Karaganda highway, a weak salt content is observed from 0.04% to 0.17%. The salinity chemistry is sulfate-bicarbonate. In the roadside territories of the Nur-Sultan-Borovoye highway, slight to very strong sulfate and chloride salinization is noted from 0.15% to 0.85%. The amount of toxic salts is 23.20%. Thus, it can be argued that the soils do not fully meet the requirements for ensuring the environmentally sustainable development of landscapes along the city's highways.

The study of the survival rate of salt-tolerant and drought-resistant species of trees and shrubs in the rural district of Kabanbay batyr, Akmola region showed that of the 18 introduced plants, 2 breeds showed good survival rate: *Acer negundo* with 96.5% and *Ulmus pumila* with 85.5%. Seven species showed satisfactory survival: *Pinus sylvestris* 79.4%; *Syringa oblata* 76%; *S. pubescens* 74%; *Ulmus laevis* 65.5%; *Amorpha fruticosa* 63.5%; *Elaeagnus angustifolia* 62.5%; *Malus* 'Royalty' 39.5%. Low survival rate was observed in 5 species: *Catalpa ovata* 17.5%; *Salix myrsinifolia* 16.5%; *Fraxinus americana* 15.5%; *Syringa reticulata* 14.5%; *Amygdalus triloba* 10.5%. Four species showed zero survival: *Fraxinus bungeana, Populus euphratica, Haloxylon persicum, Tamarix laxa*.

As a first step towards sustainable roadside plantations in this region, the species with a high survival percentage can be used. Of course, adaptation and development of these species can be supported by fertilization and other maintenance applications. However, further and continuous research for suitable dry steppe and xeric vegetation aimed for future landscaping/afforestation in Akmola region is of great importance to establish long-term sustainability.

Compliance with Ethical Standards

a) Authors' Contributions

DS, AP, and SK conceived and designed the research; DS, and AP carried out the field measurements; AP processed chemical analysis data; Chemical analyzes were mainly performed in an accredited EcoNus laboratory, GioTrade and partially by DS, and SK; SA performed and managed statistical analyses; DS, AP, and SK wrote the first draft of the manuscript; SA wrote last version of the manuscript. DS, AP, SK, SA read and approved the final manuscript; DS secured the research funding.

b) Conflict of Interest

The authors declare that there is no conflict of interest.

c) Statement on the Welfare of Animals

For this type of study is not required the ethical approval.

d) Statement of Human Rights

This study does not involve human participants.

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