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COMPARATIVE ENVIRONMENTAL AND GEOGRAPHICAL ANALYSIS OF NORTH AMERICAN SPECIES FOR ENRICHING DENDROFLORA OF FOREST RECLAMATION COMPLEXES

A.Sh. Khuzhakhmetova, S.E. Lazarev, K.A. Melnik, D.V. Sapronova

Purpose. *In this regard, the purpose of this work is to conduct a comparative ecological and geographical analysis of North American species of the genus Robinia and Gleditsia to predict the prospects for their introduction and to identify common patterns in the formation of cultigenic areas.*

Background. *Two North American species of the genus Robinia and Gleditsia (R. pseudoacacia and G. triacanthos) are currently common in protective afforestation and landscaping of settlements; other species, despite their high economic value, are used extremely rarely. Different rates of expanding cultivation areas determine the bioecological features of species that are formed under the influence of environmental and climatic conditions in the areas of their natural and secondary expansion. In this regard, the purpose of this work is to conduct a comparative ecological and geographical analysis of North American species of the genus Robinia and Gleditsia to predict the prospects for their introduction and to identify common patterns in the formation of cultigenic areas*

Materials and methods. *The objects of the current research are North American species of the genus Robinia and Gleditsia, introduced in the cluster dendrological collections of the Federal State Budget Scientific Institution «Federal Scientific Centre of Agroecology, Complex Melioration and Protective Afforestation of the Russian Academy of Sciences». Methodologically, forecasting the adaptive capabilities of the species in question under the conditions of introduction relies on the method of climatic analogs, the main provisions of which were formulated in the works of Mayr and subsequently refined by Pavari, Selyaninov, Maleev, and Good.*

Results. *The findings suggest that the major limiting factors affecting the expansion of the cultigen ranges of the species of the genus Robinia and Gleditsia are low winter temperatures (-37°C) as well as poor moisture supply and uneven distribution of precipitation in the course of the growing season.*

Conclusion. *Comparative ecological and geographical analysis of donor regions located in North America and the points of introduction in the Volgograd region have enabled us to identify the most promising species of R. neomexicana with a natural expansion area in the states of Utah, New Mexico, Arizona and Colorado, whose meteorological conditions are most similar to the ones of the Volgograd region both in terms of temperature and total precipitation. In the Gleditsia family complex, G. triacanthos was identified as having a considerable natural expansion area located in the humid and arid regions of the North American continent. This species is notable for a high level of ecological plasticity and its ability to grow in various agroforestry areas of the Volgograd region.*

Keywords: *prospects of introduction; natural, secondary, introduction and cultigenic areas; R. pseudoacacia; R. viscosa; R. neomexicana; G. triacanthos; G. × texana; G. aquatica*

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Научная статья | Лесное хозяйство

СРАВНИТЕЛЬНЫЙ ЭКОЛОГО-ГЕОГРАФИЧЕСКИЙ АНАЛИЗ СЕВЕРОАМЕРИКАНСКИХ ВИДОВ ДЛЯ ОБОГАЩЕНИЯ ДЕНДРОФЛОРЫ ЛЕСОМЕЛИОРАТИВНЫХ КОМПЛЕКСОВ

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Обоснование. *Два североамериканских вида рода Robinia и Gleditsia (R. pseudoacacia и G. triacanthos) в настоящее время широко распространены в защитном лесоразведении и озеленении населенных пунктов; другие виды,*

несмотря на их высокую хозяйственную ценность, используются крайне редко. Различные темпы расширения посевных площадей определяют биоэкологические особенности видов, которые формируются под влиянием эколого-климатических условий в районах их естественного и вторичного распространения.

Цель. *Проведение сравнительного эколого-географического анализа североамериканских видов рода Robinia и Gleditsia для прогнозирования перспектив их интродукции и выявления общих закономерностей в формировании культигенных ареалов.*

Материалы и методы. *Объектом исследования являются североамериканские виды рода Robinia и Gleditsia, интродуцированные в кластерные дендрологические коллекции Федерального государственного бюджетного научного учреждения «Федеральный научный центр агроэкологии, комплексной мелиорации и защитного лесоразведения Российской академии наук». Методологические прогнозирования адаптивных возможностей рассматриваемого вида в условиях интродукции опирается на метод климатических аналогов, основные положения которого были сформулированы в работах Майра и доработаны впоследствии Павари, Селяниновым, Малеевым и Гуда*

Результаты. *Полученные данные свидетельствуют о том, что основными лимитирующими факторами, влияющими на расширение культигенных ареалов видов рода Robinia и Gleditsia, являются низкие зимние температуры (-37°С), а также недостаточная влагообеспеченность и неравномерное распределение осадков.*

Заключение. *Сравнительный эколого-географический анализ регионов-доноров расположенных на территории Северной Америки и пунктов интродукции Волгоградской области позволил выделить наиболее перспективный вид R. neotexicana с ареалом естественного распространения на территории штатов: Юта, Нью-Мексико, Аризона и Колорадо, метеорологические условия которых имеют максимальную схожесть с Волгоградской областью как по температурным показателям, так и по общему количеству осадков. В родовом комплексе Gleditsia была выделена G. triacanthos с большим ареалом естественного распространения, расположенным во влажных и засушливых областях североамериканского континента. Данный вид отличается высоким уровнем экологической пластичности и способен произрастать в разных агролесомелиоративных районах Волгоградской области.*

Ключевые слова: *перспективность интродукции; естественные, вторичные, интродукционные, культигенные ареалы; R. pseudoacacia; R. viscosa; R. neotexicana; G. triacanthos; G. × texana; G. aquatica*

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Introduction

Species of the *Robinia* L. and *Gleditsia* L. generic complexes, with natural expansion areas located in North America, have made a considerable contribution to the formation of the gene pool of cultivated woody plants in the Volgograd region. According to the latest taxonomic evaluation [7], the genus *Robinia* includes four species of North American origin: *R. pseudoacacia* L.; *R. neomexicana* A. Gray; *R. viscosa* Vent.; *R. hispida* L. Two groups are distinguishable within the genus: the first one comprises the white-flowered *R. pseudoacacia*, a diploid cross-pollinated species, while the second one comprises the pink-flowered ones: *R. hispida, R. viscosa*, and *R. neomexicana*, which form triploid clonal races either by apomixis or by natural vegetative propagation of root offsprings [9]. The genus *Gleditsia* includes 12 species, three of which also have natural expansion areas in North America [13].

Most of the species, varieties and forms of the generic complexes of *Robinia* and *Gleditsia* are of undeniable interest for enriching the dendroflora of sparsely forested regions. They are highly drought-resistant, decorative and are distinguished by high vitality in the conditions of introduction. Unfortunately, only two species, R. *pseudoacacia* and *G. triacanthos*, have become widespread in forest reclamation complexes in the south of European Russia [1, 15].

Different rates of expanding the areas of cultivation for the species of generic complexes are associated with the bioecological characteristics of plants, which determine the limits of their resistance to adverse environmental factors. Moreover, the features of bioecology in the process of phylogenesis are affected by climatic and environmental conditions in the areas of natural and secondary expansion of species. According to ecological and geographical analysis, they can be predicted at the stage of introduction.

In this regard, the purpose of this paper is to carry out the ecological and geographical analysis of North American species of the genus *Robinia* and *Gleditsia* to predict the prospects for their introduction and to identify common patterns in the formation of cultigenic areas

The **purpose** of this work is to conduct a comparative ecological and geographical analysis of North American species of the genus *Robinia* and *Gle-*

ditsia to predict the prospects for their introduction and to identify common patterns in the formation of cultigenic areas.

Materials and Methods

The studies were conducted between 2017 and 2022. The objects of the research were North American species of the genus *Robinia* and *Gleditsia* introduced into the conditions of the Volgograd region: *R. pseudoacacia* L.; *R. neomexicana* A. Gray; *R. viscosa* Vent. and *G. triacanthos* L., *G. aquatica* Marsh.., *G. texana* Sarg. Collectible *Robinia* and honey locust plantations are located in the following areas: the nursery of woody plants of the Federal Scientific Center of Agroecology of the Russian Academy of Sciences, No. 34:34:000000:122; the Cluster Dendrological Park of Volgograd Agroforestry Research Institute, 34:34:060061:10; the administrative buildings and laboratory facilities of the Federal Scientific Center of Agroecology of the Russian Academy of Sciences, No. 34:34:060055:32; the forest seed collection plantations of the Kirov forestry in the city of Volgograd, 34:34:070010:21; the nursery of woody plants of the Nizhnevolzhskaya station for the selection of forest crops of the Federal Scientific Center of Agroecology of the Russian Academy of Sciences, No. 34:36:000014, as well as landscaping objects for general and limited use in the cities of Volgograd and Volzhsky.

Methodologically, forecasting the adaptive capabilities of the species in question under the conditions of introduction relies on the method of climatic analogs, the main provisions of which were formulated in the works of Mayr and subsequently refined by Pavari, Selyaninov, Maleev, and Good.

Agro-climatic indicators are compared at the level of the administrative-territorial division of the Volgograd region (districts) and the territories of the United States of America (states). The comparison of the climatic conditions of the natural growth regions of the specified species and the points of their introduction is based on the following indicators: absolute minimum and absolute maximum of air temperatures, average annual temperatures, as well as average annual precipitation. To identify certain patterns, we have applied multivariate analysis by the hierarchical clustering method, which was followed by constructing dendrograms.

Research results and their discussion

The Volgograd region is characterized by severe forest site conditions. The region is affected by western cyclones and arctic air masses. The air in the region is dry – eastern and southeastern dry winds are observed, which determine

the continental arid climate of the region with strong aridization in the south-eastern part [3].

Dry hot long summers followed by warm autumns, short dry springs and cold winters with temperatures down to - 37°C are common for the Volgograd region [2, 15].

The climatogram below, plotted in accordance with the long-term average data of the reference and information portal "Weather and Climate" shows the features of the annual course of the major meteorological indicators for the Volgograd region [19] (Figure 1).

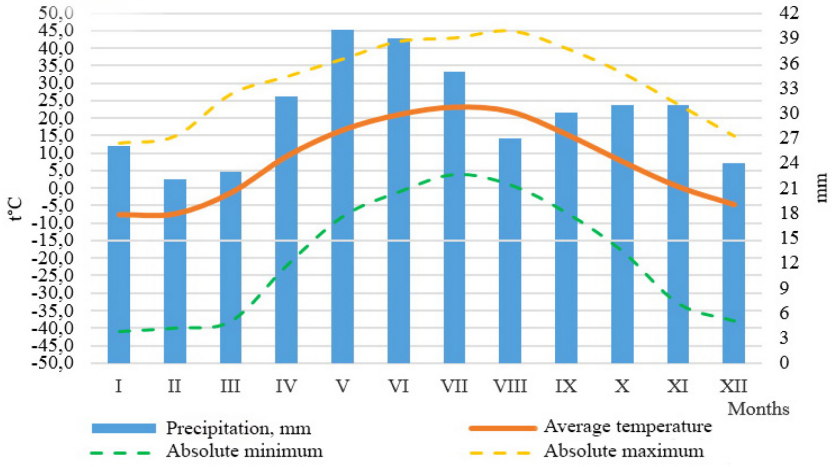

Fig. 1. Climatogram of major meteorological indicators in the Volgograd region (plotted by the authors based on the data provided by the reference and information portal "Weather and Climate" [19]).

The duration of sunshine accounts for 2079 hours in the northern part of the region with an increase up to 2350 hours in the southern regions. The region is sufficiently provided with heat. Air temperature indicators on yearly average range from 5.2 °C (the town of Elan) to 8.3 °C (the town of Kotelnikovo). The amplitude of temperature indicators is 32.9 °C per year.

The absolute maximum and minimum temperatures vary greatly from year to year, but concurrently, the difference in extreme temperatures in the districts of the region is not subject to considerable change and ranges from 850 C (in the town of Bykovo) to 770 C (in the town of Serafimovich), which is indicative of a highly continental climate [20].

The period of stable frosts begins around November, 8-9 in the north of the region, November, 16-18 in the south, and closes in late February – early March. The average duration of the frost-free period ranges between 149 days (in Elan) and 168 days (in Kotelnikovo). Dates of setting and close, the total duration of the cold period with negative average daily temperatures in the Volgograd region are close to the calendar winter and average 85-95 days [17].

The average annual humidity indicator is in the range of 66-72%. In the summer period, on some days, the humidity drops to 14 - 16%, and the average monthly figures for June - July are 54%. In winter, air humidity increases to 85% -86%.

The region witnesses frequent droughts, the frequency of which accounts for 50%. Severe droughts in the Volgograd region were observed in 1906, 1921, 1957, 1969, 1972, 1975, 1998, 2002, 2012, 2020.

On average, from 402 mm (Serafimovich) to 403 mm of precipitation (Lower Chir) falls annually in the western and southwestern districts of the region. Heavy precipitation is also characteristic of the northern part of the region: 393 mm – Yelan', 390 mm - Rudnya. The driest southern and southeastern districts are Tinguta (278 mm), Pallasovka (281 mm), Elton (292 mm). The major depth of precipitation is observed in spring and early summer, when active evaporation from the surface of the earth occurs. In summer, showers are most common with water rolling into surface watercourses, which activate soil washout and intensify erosion processes.

According to the agroforestry reclamation zoning developed by Volgograd Agroforestry Research Institute [5], the Volgograd region comprises the Volga-Don steppe, Volga-Ural and Volga-Don dry steppe, Ergeninsko-Sarpinsky and Volga-Ural semi-desert areas (Fig. 2).

The natural expansion areas of all the genus *Robinia* species are located in North America. The expansion area of *R. pseudoacacia* is Appalachian mountains from Pennsylvania to Georgia, west to Iowa, Missouri and Oklahoma. Currently, this species is widely cultivated virtually in the entire continental United States. *R. viscosa* grows in the Allegheny Mountains of eastern North America from North Carolina to Alabama.

As a highly ornamental species, it has become widespread on the east coast of North America. *R. neomexicana* is the only species with a natural range in western North America from Colorado to New Mexico, to Arizona and Utah. On the territory of the United States, *R. neomexicana* has not become widespread in culture (Fig. 3).

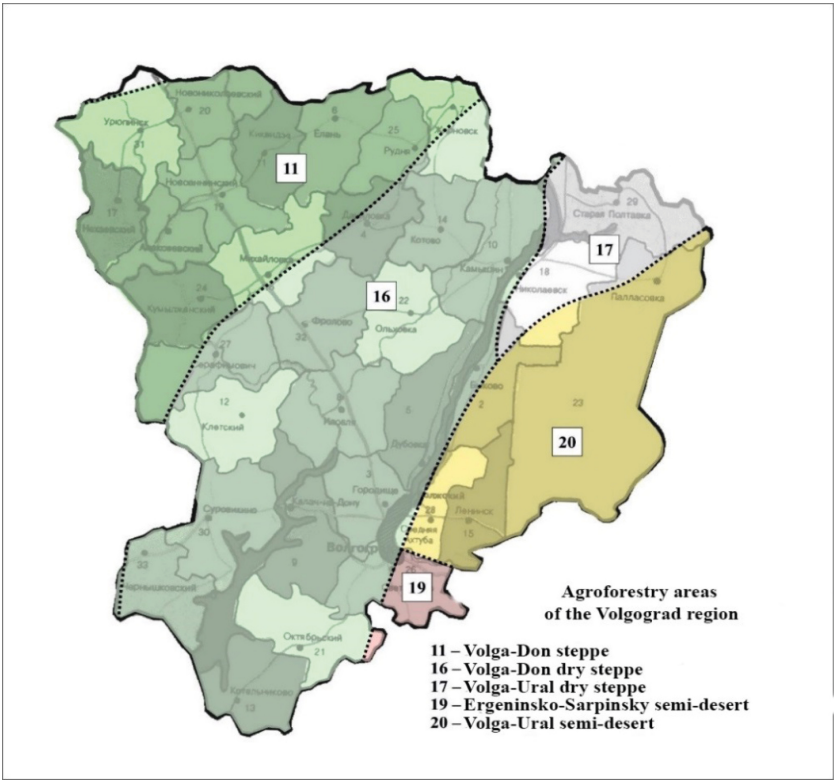

Fig. 2. Agroforestry zoning of the Volgograd region (the map has been charted by the authors based on Volgograd Agroforestry Research Institute data [3])

The natural habitats of all species of the genus *Robinia* are located in a warm subtropical climate. Therefore, the major factor, limiting the spread of this species to the north, is low winter temperatures in new cultivation conditions [8,10,14,16]. In accordance with the zoning, proposed by Reder, *Robinia pseudoacacia* and *R. viscosa* belong to the third frost resistance zone (from -35° to -20 °C), while *R. neomexicana* belongs to the fourth zone (from -20° to -10°C).

Comparison of the map of USDA plant frost resistance zones with natural expansion areas suggests that *R. neomexicana* and *Robinia pseudoacacia* have higher potential frost resistance. The expansion of the secondary ranges of *R. viscosa* and *Robinia pseudoacacia* to the north can be related to their economic value, rather than high frost resistance (Fig. 4).

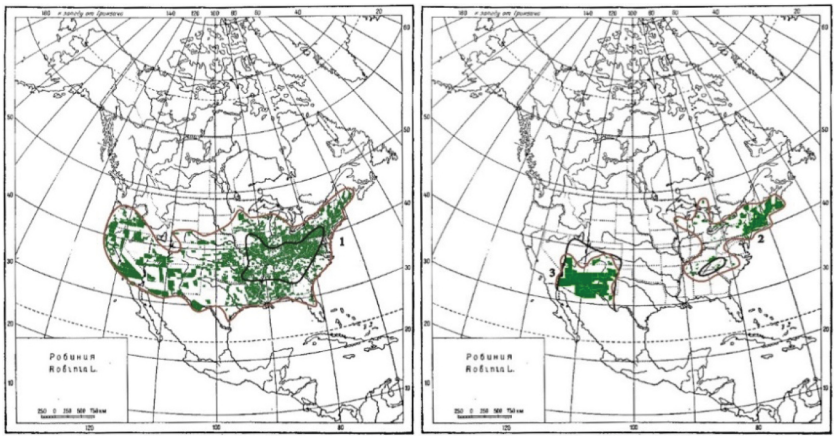

Fig. 3. Areas of natural and secondary expansion of the genus *Robinia* species in North America: 1 – *R. pseudoacacia* L., 2 – *R. viscosa* Vent., 3 – *R. neomexicana* A. Grey (charted by the authors based on the PLANTS Database [18])

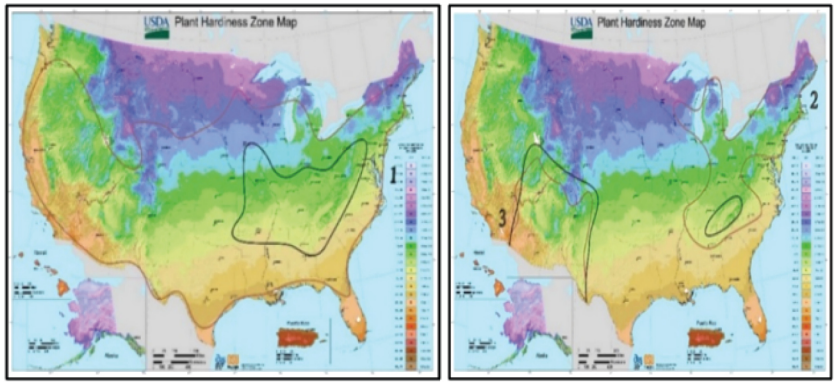

Fig. 4. Areas of natural and secondary expansion of *Robinia* species on the map of plant resistance temperature zones (USDA zones): 1 – *R. pseudoacacia*, 2 – *R. viscosa*, 3 – *R. neomexicana* (charted by the authors based on the map of USDA zones of North America)

In severe forest conditions of arid regions, the drought resistance of plants is treated as a critical bioecological characteristic. Most species of the genus *Robinia* are considered to be quite drought-resistant plants [4, 11]. Numerous researchers recommend them for creating forest reclamation complexes in arid regions across the countries and globally [5, 12].

Overlaying the natural expansion ranges of *Robinia* species on a map of average annual precipitation in North America clearly illustrates the differences in potential drought resistance. *Robinia pseudoacacia* and *R. viscosa* originate from humid subtropical forest and forest-steppe natural zones of the eastern part of the North American continent, while the natural expansion area of *R. neomexicana* is located in the western arid part of North America (Fig. 5).

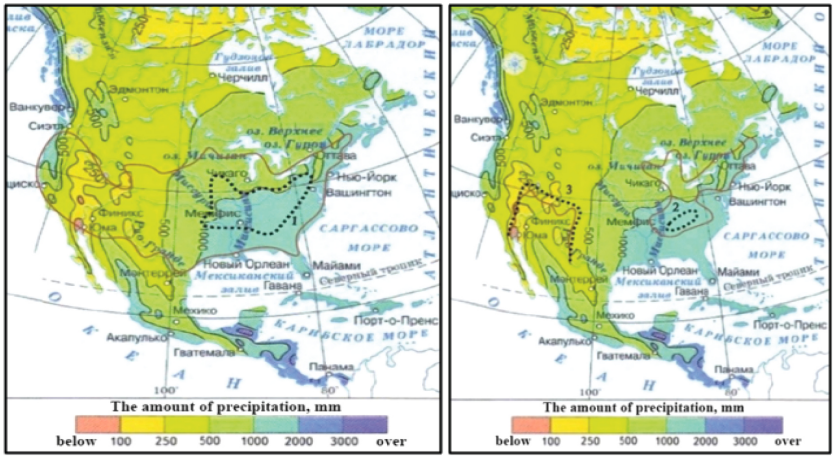

Fig. 5. Areas of natural and secondary expansion of *Robinia* species on the map of average annual precipitation in North America: 1 – *R. pseudoacacia*, 2 – *R. viscosa*, 3 – *R. neomexicana* (charted by the authors based on the map of average annual precipitation in North America)

The area of expansion of North American species of the genus *Gleditsia* is characterized by a temperate and subtropical climate, covering the southern part of the continent – from the Columbia River in the west to the Great Lakes in the east. *G. aquatica* is common in southeastern North America, from Texas to Florida, north to Kentucky and North Carolina, found in Arkansas, Tennessee, southern Mississippi and Missouri, Illinois and Indiana, rarely in eastern Mississippi. The area of natural expansion of *G. triacanthos* is central North America from western New York and Pennsylvania to southern Minnesota and eastern Kansas, south to northeast Texas and northern Georgia. The smallest natural range is of the hybrid species *G. x texana* common in the lower part of the Brazos River, in close vicinity to the cities of Brazoria and Texas.

G. aquatica is ecologically confined to floodplains, swamps and lakes. The natural expansion area is located in regions with an average annual rainfall of

2000 to 3000 mm. The largest range of *G. triacanthos* is located in large areas with an average annual rainfall of 500 to 2000 mm. (Fig. 6).

Fig. 6. Areas of natural expansion of the genus *Gleditsia* species on the contour map and the map of the average annual precipitation in North America: 1 – *G. triacanthos*, 2 – *G. aquatica*, 3 – *G. x texana* (charted by the authors on the basis of the contour map and the map of the average annual precipitation of the territory North America)

In areas of natural expansion of the genus *Gleditsia* species, the average monthly summer temperatures are 22-27 °C, winter temperatures range from 1 °C in the north to 15 °C in the south. Overlaying natural expansion areas on the cartogram of USDA frost resistance zones shows that *G. aquatica* (VIb - IXb zone with average minimum temperatures between -19° and -2.5°C) and *G. x texana* (VIIb - IXb zone between -14° and -2.5°C) are less frost-resistant. A more promising species of *G. triacanthos* is found in areas located in the Va - IXa zones with temperatures ranging from °to -5° (Fig. 7).

The agro-climatic resources of the Volgograd region differ dramatically from the ones typical for the areas of natural expansion of species in North America. Cluster analysis based on the calculation of Euclidean distances en-

ables us to group points according to the similarity of meteorological indicators of the US states, where the areas of natural expansion of the specified species are located, with meteorological indicators of various areas of the Volgograd region. The calculations take into account the average annual precipitation, the average annual temperature and the average temperature of the coldest month. The climate similarity dendrogram is shown below (Fig. 8).

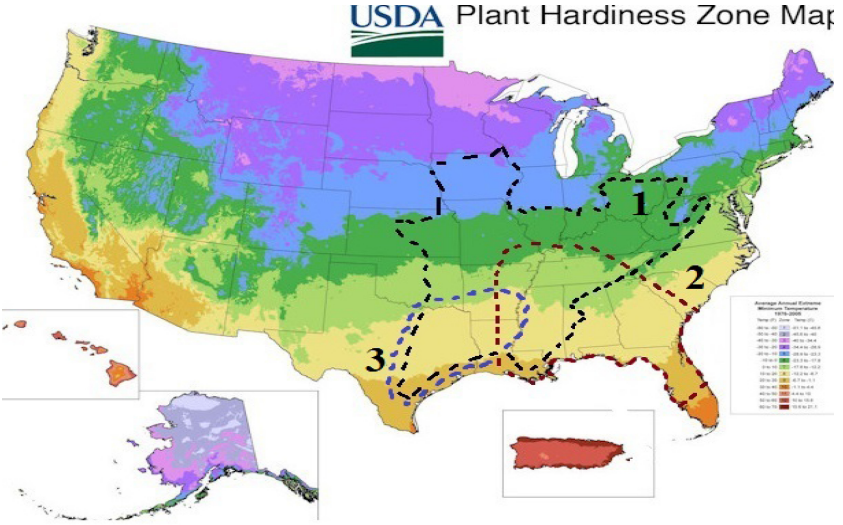

Fig. 7. Areas of natural expansion of *Gleditsia* species on the map of plant resistance temperature zones (USDA zones): 1 – *G. triacanthos*, 2 – *G. aquatica*, 3 – *G. texana* (charted by the authors based on the map of USDA zones of North America)

The states of Tennessee, Alabama, Arkansas, Missouri and Kentucky are noted for a large amount of precipitation, which results in marking them off into a separate cluster. The climate features of these states have nothing to do with any of the districts of the Volgograd region. The states of Colorado and New Mexico are the closest to the cities of Volgograd and Kotovo as well as the village of Olkhovka in terms of weather conditions.

These states also fall into a larger cluster with such urban areas as Yelan', Rudnya, Kletskaya, Uryupinsk and Ilovlya. The state of Arizona, as the most arid among the regions under consideration, can be compared with the semi-desert areas of the Volgograd region, where such settlements as Bykovo, the city of Leninsk, the city of Pallasovka, the village of Elton, the village of Tinguta are

found, and even with some settlements located on the border of the dry-steppe and semi-desert zones, i.e. the town of Dubovka and the city of Kamyshin. A separate small cluster is made up of the state of Utah and the city of Mikhailovka. In addition to the fact that their climate is quite similar in terms of precipitation (472 mm - Utah, 431 mm - the city of Mikhailovka), the state of Utah is one of the coldest states in question with an average annual temperature of 15, 7°C and an average January temperature of 3°C.

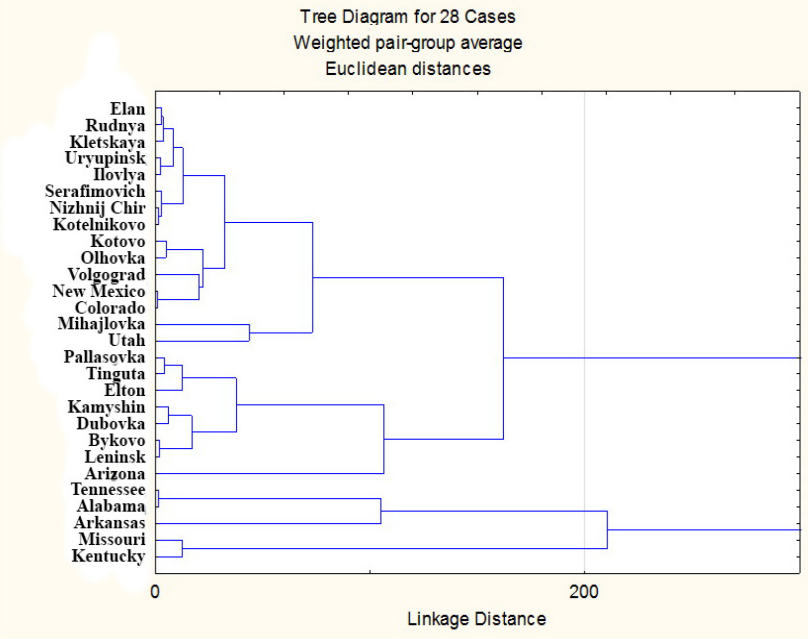

Fig. 8. Dendrogram of the climatic characteristics similarities in the areas of natural expansion of the genus *Robinia* species and the points of its introduction the Volgograd region based on Euclidean distances (compiled by the authors)

Thus, the presented analysis of the similarity of climatic indicators in natural areas and points of introduction has enabled us to identify the states of Colorado, New Mexico, Arizona and Utah as most similar to the Volgograd region in terms of their temperature and total precipitation patterns. These states form the natural expansion area of *New Mexican Robinia* which, according to the ecological and geographical characteristics, is expected to be characterized by maximum viability in the conditions of the Volgograd region.

Conclusion

The study has shown that the major limiting factors affecting the expansion of cultigen ranges of the genus *Robinia* and *Gleditsia* species on the territory of the Volgograd region are low winter temperatures (- 37°C) as well as poor moisture supply and uneven distribution of precipitation in the course of the growing season.

Comparative ecological and geographical analysis of the donor regions located in North America and the introduction points of the Volgograd region have enabled us to identify the most promising species of the generic complexes *Robinia* and *Gleditsia*.

Based on the comparative analysis of climatic characteristics, one can conclude that *R. neomexicana* has an obvious advantage over other species of the genus *Robinia*, the natural expansion area of which is located in the states of Utah, New Mexico, Arizona and Colorado. The meteorological conditions of these states have the maximum similarity to the ones of the Volgograd region both in terms of temperature and total precipitation.

In the *Gleditsia* family complex, *G. triacanthos* proved to be the most promising species with a large natural expansion area located in the humid and arid regions of the North American continent. This species has a high level of ecological plasticity and is able to grow in different agroforestry areas of the Volgograd region. The area of natural expansion of the less promising species *G. aquatica* is located in the southeastern part of the continent. This species grows in humid conditions: in floodplains, along the banks of swamps and lakes. The species of hybrid origin *G.* × *texana* occupies an intermediate position. The adaptive capabilities of this species are limited by the relatively small size of the natural range and, as a result, by low ecological plasticity.

Conflict of interest information. The authors declare that there is no conflict of interest.

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References

1. Baboshko O.I. Multifunctional role of robinium protective plantings in steppe landscapes. *Polythematic network electronic scientific journal of Kuban State Agrarian University*, 2011, no. 74, pp. 737-746.
2. Belyaev A.I., Semenyutina A.V., Khuzhakhmetova A.S., Semenyutina V.A. Analysis of Bioresource Collections on Climatic Rhythms and Phenological

Processes. *Ecological Engineering and Environmental Technology,* 2022, vol. 23, no. 3, pp. 87-94. https://doi.org/10.12912/27197050/147152

3. Brylev V.A., Geography and ecology of the Volgograd region. Volgograd. 2005, p. 259. http://obruchalka.org/20191113115528/geografiya-i-ekologiya-volgogradskoi-oblasti-brilev-v-a-2005.html?ysclid=ljs7jas23c87856389 (accessed April 07, 2022).
4. Chen J. P., Lan Z.P., Yang S.J. Water use efficiency and growth characteristics of young trees of *Robinia pseudoacacia* plantation forest under different irrigation methods in old course of Yellow river area. *Acta Ecologica Sinica*, 2015, no. 35, pp. 2529-2536. https://doi.org/10.5846/STXB201306101568
5. Cretinin V.M. Agroforestry soil science. Volgograd VNIALMI, 2009, 198 p. https://www.semanticscholar.org/paper/Evaluation-of-the-efficiency-of-irrigation-methods-Jafari-Matinkhah/372d4848ef7391b37bcea2399ac3fca81aa35d26 (accessed April 04, 2022).
6. Jafari Z., Matinkhah S.H., Mosaddeghi M.R. Evaluation of the efficiency of irrigation methods on the growth and survival of tree seedlings in an arid climate. *Journal of Arid Land,* 2020, no. 12, pp. 495-507. https:// doi.org/10.1007/s40333-020-0012-y
7. Jerzy Z., Grzegorz B., Władysław D. Pink-flowered locusts (*Robinia* L., Fabaceae) established in Poland. *Yearbook of the Polish dendrological society*, 2015, no. 63, pp. 9-33. URL: https://www.researchgate.net/publication/286924142_Rozowokwiatowe_robinie_Robinia_L_Fabaceae_dziczejace_w_Polsce_Pink-flowered_locusts_Robinia_L_Fabaceae_established_in_Poland (accessed April 07, 2022)
8. Lazarev S.E., Semenyutina A.V. Prospects of species and forms of the genus *Robinia* L. for forest protection and landscaping plantings. *Successes of modern natural science*, 2020, no. 8, pp. 11-17. https://doi.org/10.17513/use.37451
9. Lazarev S.E. Adaptation mechanisms and life strategies of species of the genus *Robinia* L. in the conditions of introduction. *World ecology journal*, 2020, vol. 10, no. 1, pp. 48-67. https://doi.org/10.25726/world journal.pro/WEB.20.1.3
10. Lazarev S.E., Semenyutina A.V., Belyaev A.I. Implementation of the tree counting process in the process of urban reclamation with the use of fuzzy neural network for agro forestry. *International Journal of Advanced Trends in Computer Science and Engineering,* 2020, vol. 9, no. 4, pp. 6232-6237. https://doi.org/10.30534/ijatcse/2020/302942020
11. Morozova E.V., Iozus A.P., Kryuchkov S.N. The main results of the breeding of robinia false acacia in the Lower Volga region. *Successes of modern natural science*, 2018, no. 12-2, pp. 290-295. https://natural-sciences.ru/ru/article/view?id=37010&ysclid=ljsacc64xn313799382 (accessed April 07, 2022).

12. Nan G., Wang N., Jiao L. A new exploration for accurately quantifying the effect of afforestation on soil moisture: A case study of artificial *Robinia pseudoacacia* in the Loess Plateau (China). *Forest Ecology and Management*, 2019, no. 433, pp. 459-466. https://doi.org/10.1016/J.FORECO.2018.10.029
13. Semenyutina A.V., Klimov A.D. Analysis of bioresources of the *Robinia, Gleditsia* gene pool for forest reclamation complexes based on the study of adaptation to stress. *World ecology journal,* 2018, vol. 8, no. 2, pp. 33-45. https://doi.org/10.25726/NM.2018.2.2.004
14. Semenyutina A.V., Svintsov I. P., Khuzhakhmetova A. Sh. Mobilization of dendrological resources and ways of preserving their biodiversity in low-forest regions. Volgograd: Federal Scientific Center of Agroecology, Integrated Land Reclamation and Protective Afforestation of the Russian Academy of Sciences, 2021, 288 p.
15. Semenyutina A.V., Svintsov I. P., Khuzhakhmetova A. Sh. Regulations of safe and sustainable use of biodiversity of woody plants in protective afforestation. *Journal of Agriculture and Environmen*t, 2018, vol. 3(7), p. 3. https://doi.org/10.23649/jae.2018.3.7.3.
16. Semenyutina A.V., Melnik K.A., Semenyutina V.A. Assessment of Growth and Development of Representatives under the Conditions of Chestnut Soils. *Ecological Engineering and Environmental Technology*, 2022, vol. 23, no. 1, pp. 19-24. https://doi.org/10.12912/27197050/143136
17. Sitzia T., Cierjacks A., de Rigo D., Caudullo G. *Robinia pseudoacacia* in Europe: distribution, habitat, usage andthreats. *European Atlas of Forest Tree Species*, 2016, pp. 166-167. URL: https://forest.jrc.ec.europa.eu/media/atlas/Robinia_pseudoacacia.pdf (accessed April 05, 2022).
18. The Plants Database. 2018. URL: https://plants.sc.egov.usda.gov/java/nameSearch (accessed April 07, 2022).
19. Weather and Climate. 2021. URL: http://www.pogodaiklimat.ru/history/34560.htm (accessed April 07, 2022).
20. Yildiz O., Altundağ E., Çetin B. Experimental arid land afforestation in Central Anatolia, Turkey. *Environmental Monitoring and Assessment*, 2019, vol. 190, no. 6. https://doi.org/10.1007/s10661-018-6724-1

Список литературы

1. Бабошко О.И. Многофункциональная роль робиниевых защитных насаждений в степных ландшафтах // Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета. 2011. № 74. С. 737-746.

2. Belyaev A.I., Semenyutina A.V., Khuzhakhmetova A.S., Semenyutina V.A. Analysis of Bioresource Collections on Climatic Rhythms and Phenological Processes // Ecological Engineering and Environmental Technology. 2022. Vol. 23, No. 3. P. 87-94. https://doi.org/10.12912/27197050/147152
3. Брылев В.А. География и экология Волгоградской области. Волгоград, 2005. 259 с. URL: https://obuchalka.org/20191113115528/geografiya-i-ekologiya-volgogradskoi-oblasti-brilev-v-a-2005.html?ysclid=ljs7jas23c87856389 (дата обращения: 07.07.2023).
4. Chen J.P., Lan Z.P., Yang S.J. Water use efficiency and growth characteristics of young trees of *Robinia pseudoacacia* plantation forest under different irrigation methods in old course of Yellow river area // Acta Ecologica Sinica. 2015. No. 35. P. 2529-2536. https://doi.org/10.5846/STXB201306101568
5. Кретинин В.М. Агролесомелиорация почв. Волгоград: ВНИАЛМИ, 2009. 198 с. URL: https://www.semanticscholar.org/paper/Evaluation-of-the-efficiency-of-irrigation-methods-Jafari-Matinkhah/372d4848ef7391b37bcea2399ac3fca81aa35d26 (дата обращения: 07.07.2023).
6. Jafari Z., Matinkhah S.H., Mosaddeghi M.R. Evaluation of the efficiency of irrigation methods on the growth and survival of tree seedlings in an arid climate // Journal of Arid Land. 2020. No. 12. P. 495-507. https://doi.org/10.1007/s40333-020-0012-y
7. Jerzy Z., Grzegorz B., Władysław D. Pink-flowered locusts (*Robinia* L., Fabaceae) established in Poland // Yearbook of the Polish dendrological society. 2015. No. 63. P. 9-33. URL: https://www.researchgate.net/publication/286924142_Rozowokwiatowe_robinie_Robinia_L_Fabaceae_dziczejace_w_Polsce_Pink-flowered_locusts_Robinia_L_Fabaceae_established_in_Poland (accessed April 07, 2022)
8. Лазарев С.Е., Семенютина А.В. Перспективность видов и форм рода Robinial. Для лесозащитных и озеленительных насаждений // Успехи современного естествознания. 2020. № 8. С. 11-17. https://doi.org/10.17513/use.37451
9. Лазарев С.Е. Механизмы адаптации и жизненные стратегии видов рода Robinia L. в условиях интродукции // World ecology journal. 2020. Т 10. №1. С. 48-67. https://doi.org/10.25726/worldjournals.pro/WEJ.2020.1.3
10. Lazarev S.E., Semenyutina A.V., Belyaev A.I. Implementation of the tree counting process in the process of urban reclamation with the use of fuzzy neural network for agro forestry // International Journal of Advanced Trends in Computer Science and Engineering. 2020. T. 9, No 4. P. 6232-6237. https://doi.org/10.30534/ijatcse/2020/302942020
11. Морозова, Е. В., Иозус А. П., Крючков С. Н. Основные итоги селекции робинии лжеакации в Нижнем Поволжье // Успехи современного естествознания. 2018. № 12-2. С. 290-295. URL: https://natural-sciences.ru/ru/article/view?id=37010&ysclid=ljsacc64xn313799382 (дата обращения: 07.07.2023).

12. Nan G., Wang N., Jiao L. A new exploration for accurately quantifying the effect of afforestation on soil moisture: A case study of artificial *Robinia pseudoacacia* in the Loess Plateau (China) // Forest Ecology and Management. 2019. No 433. P. 459-466. https://doi.org/10.1016/J.FORECO.2018.10.029
13. Семенютина, А. В., Климов А. Д. Анализ биоресурсов генофонда Robinia, Gleditsia для лесомелиоративных комплексов на основе изучения адаптации к стрессу // World ecology journal. 2018. Т. 8, № 2. С. 33-45. https://doi.org/10.25726/NM.2018.2.2.004
14. Семенютина А. В., Свинцов И. П., Хужахметова А. Ш. Мобилизация дендрологических ресурсов и пути сохранения их биоразнообразия в малолесных регионах. Волгоград: Федеральный научный центр агроэкологии, комплексных мелиораций и защитного лесоразведения Российской академии наукб 2021. 288 с.
15. Semenyutina A.V., Svintsov I. P., Khuzhakhmetova A. Sh. Regulations of safe and sustainable use of biodiversity of woody plants in protective afforestation // Journal of Agriculture and Environment. 2018. Vol. 3(7). P. 3. https://doi.org/10.23649/jae.2018.3.7.3
16. Semenyutina A.V., Melnik K.A., Semenyutina V.A. Assessment of Growth and Development of Representatives under the Conditions of Chestnut Soils // Ecological Engineering and Environmental Technology. 2022. Vol. 23, №1. P. 19-24. https://doi.org/10.12912/27197050/143136
17. Sitzia T., Cierjacks A., de Rigo D., Caudullo G. *Robinia pseudoacacia* in Europe: distribution, habitat, usage andthreats // European Atlas of Forest Tree Species. 2016. P. 166-167. URL: https://forest.jrc.ec.europa.eu/media/atlas/Robinia_pseudoacacia.pdf (accessed April 05, 2022).
18. The Plants Database. 2018. URL: https://plants.sc.egov.usda.gov/java/nameSearch (accessed April 07, 2022).
19. Weather and Climate. 2021. URL: http://www.pogodaiklimat.ru/history/34560.htm (accessed April 07, 2022).
20. Yildiz O., Altundağ E., Çetin B. Experimental arid land afforestation in Central Anatolia, Turkey // Environmental Monitoring and Assessment. 2019. Vol. 190, No. 6. https://doi.org/10.1007/s10661-018-6724-1

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