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# Ecological role of introduced species and autochthon plants in protective tree belts of South Siberia

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**Abstract.** Assessment of the condition and morphological structure of tree species that constitute protective forest belts in southern Siberia has shown that plants perform ecological and economic functions under the most extreme conditions. The regions of Southern Siberia are characterized by a complex of negative environmental factors that have an adverse effect on the condition and growth of tree species of protective forest belts (soil conditions, lack of moisture, strong wind, salinization and deflation processes). Poplar and elm are used as introduced species in protective forest belts in South Siberia. Plants are characterized by intensive growth and average salt tolerance. Protective forest belts of autochthonous plant species (birch, pine, larch) have a more satisfactory condition compared to introduced species. However, poplar and elm grow in more difficult conditions (steppe areas of Khakassia), which determines their condition. In terms of growth intensity, as well as horizontal protection, introduced species largely exceed autochthonous plant species. Key words: protective forest belt, introduced species, autochthonous plants, condition, morphological characterization

## 1 Introduction

In the new system of economic relations in Russia, less and less attention is paid to the development of field-protective forest belts. However, the problems of arid territories (intensification of erosion processes, deflation, soil salinization) in the conditions of climate warming require a number of activities and development of programs, both at the national and international levels [1]. The system of protective forest belts created in the Soviet times solves a set of practical and ecological problems [1, 2, 3, 4].

The southern regions of Krasnoyarsk Krai are characterized by high continental climate; low precipitation; lack of stable snow cover; high air velocities in the surface layer in the

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pre-spring and spring months, usually accompanied by dust storms and frequent droughts [5]. In addition to these factors, A.V. Ogorodnikov [6] pointed to unfavorable soil conditions observed in the Shirinsky steppe, salinity of the soil-soil stratum and transport of fine-grained soils.

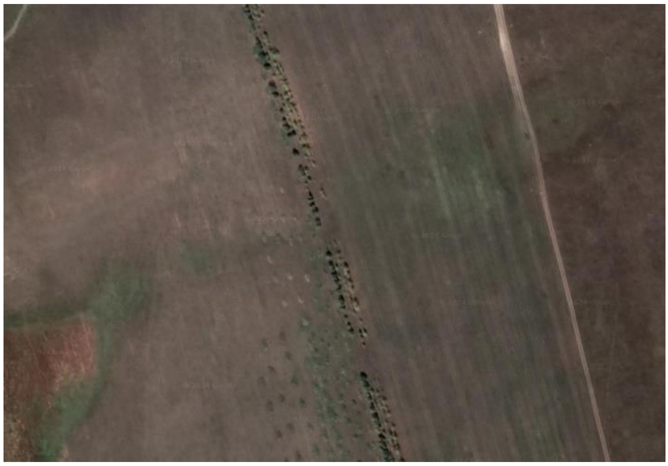
Under such conditions, assessment of the condition and morphology of trees in protective forest belts assortatively represented mainly by introduced species is an urgent and significant task.

## 2 Methods and materials

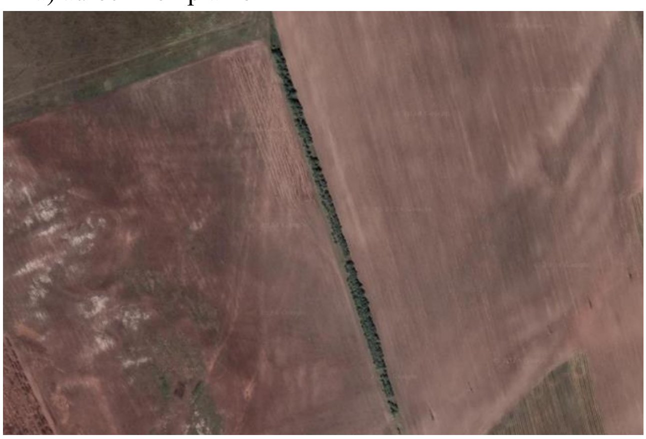
Studies in protective forest belts were conducted for 2 years. On the territory of the Republic of Khakassia (Ust-Abakansky, Beysky, Shirinsky, Shushensky districts), Minusinsky district of Krasnoyarsky Krai and the Republic of Tyva (Kazylsky district) sample areas were laid in accordance with OST 56-69-83 [7]. Measurement of morphological features was carried out in accordance with generally accepted methods [8, 9]. Calculation of average estimated parameters was carried out according to taxation requirements [10]. The condition of the stands was determined according to the scale of sanitary condition: I - healthy without signs of weakening; II - weakened; III - moderately weakened; IV - severely weakened (shrunken); V - fresh drywood (current year); VI - old drywood (previous years). The age of stands at the time of observations ranged from 26 to 47 years. The plantations grew predominantly on southern and ordinary chernozems; in addition, salinization and placement on sandy soils were detected in some areas. The assortment of tree and shrub species is represented by B - birch *(Betula pendula E.)*, S - Siberian elm *(Ulmus pumila L.)*, L - Siberian larch *(Larix sibirica L.*), C - common pine (*Pinus sylvestris L*.), P - black poplar (*Populus nigra L*.), Psh – Siberian pea shrub (*Karagana arborescens L*.).

Protective belts are represented mainly by homogeneous pure stands, the stability of which is higher in arid conditions [1, 5]. However, there were stands with combinations of elm, poplar and pea shrub, as well as joint growth of pine, larch and birch. The number of rows in the strips is from 1 to 7. The method of establishment is predominantly row-based. Rare, staggered planting was observed in birch, elm and larch trees. The mixing pattern was in accordance with the recommendations for the creation of protective strips. Density depended on the mixing scheme adopted and subsequent plant dieback. The strips were presented from openwork to dense construction depending on the purpose and the tree species represented. The characterization of plantations in the sample plots indicated the species and structural diversity of the created protective strips.

Protective forest belts of the Republic of Khakassia are presented in Figure 1:



a) autochthon plants



b) introduced species

**Fig. 1.** Protective tree belts of the Republic of Khakassia

Processing of the initial material was carried out using the spreadsheet "Excel", statistical program "Statistica" and database created in "Access".

## 3 Results and Discussion

Effective fulfillment of ameliorative tasks by protective strips is possible only in case of stable growth, condition and longevity of plantations. All this largely depends on the species assortment of strips. Elm squat and black poplar can be considered as fully introduced species. The other plants do not form continuous forests in steppe and forest-steppe areas, but they grow in areas of Southern Siberia. Therefore, they can be referred to autochthon plants species.

The comparative analysis showed that the condition of protective strips of autochthon plants species is more satisfactory than that of tree species. At the same time, it should be noted that the protected strips were created in the conditions of steppe areas of Khakassia, characterized by a whole range of unfavorable conditions, and without the use of introduced species plants, sustainable and durable growth of the strips is impossible. For example, Siberian elm and tree-like caragana are characterized by average salt tolerance, and black poplar by intensive growth. The longevity of all species by rows decreases, which indicates, on the one hand, the increase in the fall of trees from the first to the last row, and on the other hand, the size of plants. The first row is the most stable, which is associated with accumulation of both nutrients and moisture in the first row, which in arid conditions is crucial for plant growth.

Evaluation of average morphological species allows us to establish the fulfillment of functional purpose by protective strips. Table 1 shows the morphological characteristics of trees growing in protective tree belts.

**Table 1.** Average morphological characteristics of trees of the assigned track in South Siberia.

| Trial area | Structure | Main species | A, years | H, m | D, cm | Lc, m | Dc in r., m | Dc bet. r., m |
|---|---|---|---|---|---|---|---|---|
| Introduced species | | | | | | | | |
| 4 | OW | S | 29 | 8.6 | 15.9 | 6.0 | 3.0 | 4.4 |
| 5 | Bl | S | 27 | 8.1 | 12.1 | 4.9 | 2.7 | 4.1 |
| 6 | Bl | S | 27 | 8.3 | 13.2 | 5.3 | 2.8 | 3.8 |
| 7 | V-Bl | S | 27 | 10.8 | 16.5 | 7.4 | 3.8 | 4.1 |
| 8 | D | S | 27 | 6.2 | 9.5 | 4.8 | 2.4 | 2.8 |
| 9 | OW | S | 29 | 4.9 | 8.3 | 3.0 | 2.7 | 3.0 |
| 10 | OW | S | 29 | 5.7 | 8.9 | 4.0 | 2.9 | 2.9 |
| 8 | D | P | 26 | 9.3 | 14.4 | 7.5 | 3.9 | 4.7 |
| 19 | D | P | 27 | 8.7 | 17.1 | 7.1 | 3.8 | 4.5 |
| 21 | Bl | P | - | 17.2 | 28.5 | 14.4 | 5.4 | 6.7 |
| 22 | Bl | P | - | 11.5 | 20.4 | 10.0 | 4.3 | 4.9 |
| 23 | Bl | P | - | 14.2 | 22.5 | 10.0 | 4.4 | 4.4 |
| Autochthon plants | | | | | | | | |
| 1 | Bl | B | 27 | 10.4 | 14.2 | 7.8 | 2.5 | 3.7 |
| 2 | Bl | B | 27 | 10.4 | 14.4 | 7.7 | 3.0 | 4.3 |
| 3 | V-Bl | B | 27 | 9.9 | 13.1 | 7.4 | 2.8 | 4.0 |
| 17 | D | B | 34 | 11.2 | 12.2 | 8.6 | 2.3 | 3.2 |
| 18 | D | B | 34 | 12.6 | 14.4 | 10.4 | 3.6 | 2.8 |
| 17 | D | C | 34 | 7.8 | 13.0 | 5.2 | 2.0 | 3.8 |
| 18 | D | C | 34 | 7.8 | 13.2 | 5.2 | 2.3 | 2.7 |
| 11 | V-Bl | L | - | 5.8 | 12.5 | 3.9 | 3.1 | 3.5 |
| 12 | Bl | L | - | 5.9 | 11.9 | 3.9 | 3.2 | 3.3 |
| 13 | Bl | L | 29 | 7.9 | 16.2 | 5.2 | 3.1 | 4.4 |

Note: A- age, years; H - height, m; D - average diameter, cm; Lc - crown length, m; Dc in r. - crown diameter in a row, m; Dc bet. r. - crown diameter between rows, m. The results were obtained at a confidence level of 95.4%. Design: OW - openwork, Bl - blown, D - dense, V-Bl - vertically blown.

Age determines the longevity of protective forest belts. In general, it can be stated that according to L.S. Savelieva, trees are in the period of weakening of physiological processes (age from 27 to 34 years). Protective height depends on a complex of both biological and economic factors. M.A. Shary [11] noted that the height increment of the central shoot is the main criterion of viability of a woody plant. The Siberian elm had a height from 4.9 to 10.8 m; black poplar from 8.7 to 17.2 m; birch from 9.9 to 12.6 m; common pine 7.8 m;

Siberian larch from 5.8 to 7.9 m. Crown space plays the main role in protective tree belt functions. Siberian elm - crown length varied from 3.0 to 7.4 m; black poplar from 7.1 to 14.4 m; birch from 7.4 to 10.4 m; common pine 5.2 m; Siberian larch from 5.8 to 7.9 m. In terms of crown length, the species can be arranged in the following order (vertical protection): black poplar, birch, Siberian larch, Siberian elm and common pine. It should be noted that conifers may change the order of vertical protection in the given conditions of habitat with increasing age and preservation of protective strips.

The crown diameter of trees in protective tree belts depends mainly on the distance between and within rows. As a result, we can state that in terms of crown diameters in rows (horizontal protection) plants had the following sizes: Siberian elm from 2.4 to 3.8 m; black poplar from 3.8 to 5.4 m; birch from 2.3 to 3.6 m; common pine from 2.0 to 2.3 m; Siberian larch from 3.1 to 3.2 m. In this case, taking into account horizontal protection, the species can be arranged in the following order: black poplar, Siberian elm, birch, Siberian larch and common pine.

## 4 Conclusions

Summarizing the above, the following conclusions were obtained.

- Climate warming makes us pay attention to the growing conditions of agrocenoses (protective tree belts) in arid territories. The study of morphological structure of tree species and autochthon plants allows us to study the existence of tree species under extreme climate conditions.

- The regions of South Siberia are characterized by a complex of negative environmental factors that adversely affect the condition and growth of tree species of protective tree belts (soil conditions, lack of moisture, strong wind, salinization and deflation processes).

- In protective tree belts of South Siberia poplar and elm are used as introduced species. Plants are characterized by intensive growth and average salt tolerance.

- Protective tree belts of autochthonous plant species (birch, pine, larch) have more satisfactory condition in comparison with introduced species. However, poplar and elm grow in more difficult conditions (steppe areas of Khakassia), which determines their condition.

- The first row in protective tree belts turned out to be the most stable both in terms of number of trees and size, regardless of tree species. The creation of non-multi-row strips should be recommended in these conditions.

- Deciduous species are characterized by a higher protective strip compared to conifers.

- In terms of crown length (vertical protection), black poplar has the maximum dimensions, and the minimum dimensions are found in Siberian elm and common pine.

- Crown diameter of trees in rows determines horizontal protection. Maximum parameters have trees of introduced species in contrast to autochthonous plant species.

Thus, the assessment of the condition and morphological structure of tree species that make up protective forest belts in South Siberia has shown that introduced species plants perform ecological and economic functions in the most extreme conditions, and they significantly exceed autochthonous plant species in terms of growth intensity and horizontal protection.

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