Condition assessment of species of the genus *Pseudotsuga* Carr in Voronezh in order to predict seed productivity in the urban environment

Yu V Chekmeneva* and V D Dorofeeva

Department of Botany and Plant Physiology, Voronezh State University of Forestry and Technologies named after G.F. Morozov, 8 Timiryazeva street, Voronezh 394087, Russian Federation

*E-mail: lf_chekmeneva@vgltu.ru

Abstract. In the conditions of the Central Black Earth region, in the park plantations of the city of Voronezh, the categories of tree conditions and seed productivity of the genus *Pseudotsuga* Carr were compared. Estimated yield, linear parameters of cones and seeds. The average values and the amplitude of the variability of the morphometric parameters of cones and seeds are determined. It was shown that in urban conditions at different objects the variability of attributes increases and the category of condition worsens for trees that grow in close proximity to roads, and are also in a depressed state due to shadowing by neighboring trees. The possibility of phenotypic selection of trees for stability in an urban environment by the level of variability of the parameters of the generative sphere is considered. It was revealed that variability at the level of cultivated phytocenoses is weakly expressed than that of individual trees at the endogenous level. In this regard, selection requires a more in-depth study of the polymorphism of cones and seeds to identify correlative traits associated with tree productivity indices.

1. Introduction

According to the studies, introduced species in the areas of introduction have a more intensive growth, they are used to increase the productivity of plantations and obtain high-quality wood in forestry, expand the species composition and increase the sustainability of green spaces in the urban environment [1]. Current changes in forest management and global climate change necessitate increasing the sustainability of forest and urban plantations [2, 3].

One of the urgent tasks of introduction studies is propagation in culture and obtaining sufficiently large introduced populations in order to preserve plants for further use in forestry and parks. When introduced under changing conditions, specific species features of the development of the generative and vegetative spheres appear [4, 5]. The experimental studies of the characteristics of plant adaptation outside its range contribute to the identification of plasticity of species, forms, rhythm of development of the stages of ontogenesis, introduction resistance, the identification of adaptation processes to new conditions of existence. To create sustainable, promising plantings in an urbanized environment, as well as to improve the landscape appearance of squares and parks, boulevards, highways, it is possible to use plants of different forms. Scientifically substantiated selection of the assortment of species,
taking into account its biological properties, decorative qualities, and adaptation features in the introduction zone, determines the stability of the stands in the urban environment.

Over 100 years of *Pseudotsuga* Carr breeding experience has shown that this forest-forming North American species has rapid growth, high productivity, valuable physicomechanical properties of wood, and resistance to adverse environmental factors; it can be grown in many regions of Russia. In the conditions of the Central Black Earth Region, *Pseudotsuga* Carr is of practical interest for afforestation and landscaping.

The work purpose is the identification of resistant species, forms of the genus *Pseudotsuga* Carr in urban conditions on the example of Voronezh. The objectives of the study included: assessment of the categories of the state of the species in the parkland of Voronezh, assessment of seed productivity; to identify biologically stable species, forms in the urban environment for the Central Black Earth Region, evaluating the phenotypic variability of the characters of the generative sphere.

Voronezh is located in the Central Black Earth Region and is characterized by a temperate continental climate. In the central district, the number of days with temperatures above 0°C is 220-270 days. The duration of the growing season ranges from 180 to 190 days. The average rainfall is 150-550 mm. During the growing season, 270-315 mm of precipitation falls. In May-September, droughts are often observed, that is, within the natural range of *Pseudotsuga*, the total amount of precipitation is 2 times higher than in the Central Black Sea. However, in the summer months in the compared areas, almost the same amount of precipitation falls. Humidity in the homeland of this breed is almost uniformly high throughout the year, with an average of 60-70% in the Central Black Earth. It should be noted that significant natural and atmospheric droughts are often observed in the natural range. In the conditions of the forest-steppe *Pseudotsuga* is of practical interest, both for afforestation and for green construction [6].

In urban plantations of the European part of Russia, there are about 500 species and forms of woody exotics, not counting decorative forms. Currently, more than 50 species and forms of coniferous introducers grow in the urban plantations of Voronezh. The predominant species from the Pinaceae Lindl. family are *Picea abies* (L.) Karst., *Picea pungens* Engel. and its cultivated species, *Picea canadensis*, *Larix sibirica* Ledeb., *Pseudotsuga menziesii* (Mirb.) Franco, the Cupressaceae Bartl. family - *Thuja occidentalis* L., *Platycladus orientalis* (L.) Franco and other species. Most forms of introduced conifers by origin belong to the Circumboreal, East Asian, Atlantic and North American floristic regions. During the introduction, species from areas where the temperature curve coincides with the temperature curve of the introduction sites will differ most in stability, this corresponds to the method of climatic analogues of G. Mayr [7]. The ideas of plant introduction, close to Mayr's theory, were developed by A. Pavari (1916) [8] and G.T. Selyaninov (1928-1929) [9]. The main criterion when working with the method of horizontal introduction is the selection of climatic analogues and areas of future introduction and reintroduction of plants within the same latitude, similar natural mountain belts from the southern and northern hemispheres or territories adjacent to it (ecotopes), where the most labile ecotypes are concentrated. [10, 11].

Our research focused on assessing the status and reproductive categories of *Pseudotsuga menziesii* (Mirb.) Franco in urban artificially created populations (cultural phytocenoses). This species has three varieties - *menziesii* (*Pseudotsuga menziesii*), gray (*Pseudotsuga caesia*), and white (*Pseudotsuga glauca*). *Pseudotsuga menziesii* grows in vast areas of western North America from Canada to Northern Mexico, along the Pacific coast, the slopes of the coastal ridge and the Rocky Mountains, rising to 1000-2250 m above sea level. Within a vast area with diverse soil and climatic conditions, two varieties are distinguished: the green *Pseudotsuga*, or the coastal and the *Pseudotsuga* bluish, or the mainland (mountain). The coastal form is more demanding on-air humidity, it can be damaged by late spring frosts, and the mountain form - *Pseudotsuga glauca* shows great stability [12]. Forms of *Pseudotsuga*, growing in the southern part of the range, grow rapidly, start to grow early, and are therefore sensitive to low temperatures. With the rise in the mountains, it is frost-resistant, but characterized by slow growth. A variety of environmental conditions affects the polymorphism of the species. Green needles, large cone sizes, rapid growth from the first years of life of *Pseudotsuga* are
combined with a lower level of adaptability to adverse climatic conditions, and vice versa needles with a blue or gray shade, smaller cones, smaller growth energy - this species is more resistant to adverse climatic conditions.

It is important to take into account the ecological features of climatypes when introducing them, since different climatypes adapt differently to new climatic conditions outside their natural range. This makes it necessary to study the adaptive abilities of introducers and select the most valuable specimens in order to preserve and reproduce it [13]. In the conditions of culture, the place of preservation of the pheno- and gene pool is the collection plantings. In the practice of green building, there is a need to improve methods for selecting an assortment of sustainable and promising tree species, which will increase the quality of ecosystem services of urban green spaces.

2. Objects and methods
Observations were carried out on forty-four trees of Pseudotsuga menziesii (Mirb.) Franco, growing in parklands of the city of Voronezh. The assessment of the condition category was determined according to the scale for conifers: 1 - healthy (without signs of weakening), 2 - weakened - the crown is sparse; the needles are light green; growth is reduced, but not more than half; individual branches dried up, 3 - strongly weakened - openwork crown; needles are light green, matte; growth is weak, less than half the usual; drying of branches up to 2/3 of the crown; fruit bodies of fungi or hollows characteristic of it, 4 - drying out - the crown is very openwork; the needles are gray, yellowish or yellow-green; growth is very weak or absent; drying of more than 2/3 of the branches, 5 - fresh dead wood - gray needles, yellow or red-brown; the bark is partially opal, 5 (a) - freshly vetted; the needles are green, gray, yellow or red-brown; the bark is usually lively, the trunk is felled or tilted with a cliff of more than 1/3 of the roots, 5 (b) - fresh windbreak - green, gray, yellow or red-brown needles; the bark below the crowbar is usually live, the trunk is broken below 1/3 of the crown length, 6 - old dead wood - no live needles (foliage); bark and small twigs showered partially or completely; stem pests flew out; in the trunk of the mycelium of wood-destroying fungi, outside the fruiting bodies of tinder fungi, 6 (a) - the old veiled - live needles (foliage) are absent; bark and small twigs showered partially or completely; the trunk is felled or tilted with a cliff of more than 1/3 of the roots; stem pests flew out, 6 (b) - an old windbreak - no live needles (foliage); bark and small twigs showered partially or completely; the trunk is broken below 1/3 of the length of the crown; stem pests flew above the site of breakage; below the place of breakage there may be: live bark, water shoots, secondary crown, fresh stem pest settlements, 7 - emergency trees-trees with structural defects (presence of hollows, rot, clipping of roots, dangerous slope) that can lead to the fall of the whole tree or its parts and causing damage to the population or state property and property of citizens [14].

Accounting for the crop was carried out according to the method of A.A. Korchagin [15]. Quantitative and reproductive characteristics of cones, seed scales, seeds were evaluated. Twenty-five cones were collected from each tree. The level of variability of morphological characters was evaluated on the empirical scale of S. A. Mamaev's levels of variability: very low (C < 7%), low (C = 8-12%), medium (C = 13-20%), increased (C = 21 - 30%), high (C = 31 - 40%), very high (C > 40%) [16]. The results were processed on a computer using Microsoft Excel. The accuracy of the experiment is in the range of 5-6%.

3. Main part
The studied species grow in urban plantations of the city of Voronezh, in the zone of heavy traffic and high anthropogenic load. The observations were made over forty-four trees. The quantitative distribution of trees by steps of thickness (trunk diameter at chest height) depending on the height is shown in table 1.

Features of the growth of trees in diameter depending on height are shown in figure 1. On the graphs, an approximation is carried out by a polynomial function in height and thickness steps. To increase the accuracy of the determination coefficient, a polynomial function (2nd degree) of a different number of trees was used — the dependence is nonlinear. The functional relationship in this case is as
follows and is expressed by the formula in steps of thickness: \( y = -0.0247x^2 + 0.3247x + 2.5714 \); height: \( y = -0.0379x^2 + 0.3076x + 4.3667 \). The reliability of the approximation fluctuates and reaches 0.51.

**Table 1.** Distribution of trees by thickness steps depending on height.

| diameter, cm | 6   | 8   | 10  | 12  | 14  | 16  | 18  | 20  | 22  | 24  | number of trees, pcs |
|--------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----------------------|
| height of a tree, m |     |     |     |     |     |     |     |     |     |     |                       |
| 12           | 2   |     |     |     |     |     |     |     |     |     | 4                     |
| 16           |     | 1   |     |     |     |     |     |     |     |     | 1                     |
| 20           |     |     | 1   |     |     |     |     |     |     |     | 7                     |
| 24           |     |     |     | 1   |     |     |     |     |     |     | 1                     |
| 28           | 2   |     |     |     | 1   |     |     |     |     |     | 3                     |
| 32           |     |     |     |     |     | 1   |     |     |     |     | 1                     |
| 36           |     |     |     |     |     |     | 1   |     |     |     | 3                     |
| 40           | 1   |     |     |     |     |     |     | 2   |     |     | 3                     |
| 44           |     |     |     |     |     |     |     |     | 1   |     | 7                     |
| 48           |     |     |     |     |     |     |     |     |     | 1   | 1                     |
| 52           |     |     |     |     |     |     |     |     |     | 2   | 2                     |
| 54           |     |     |     |     |     |     |     |     |     |     | 1                     |
| 58           |     |     |     |     |     |     |     |     |     | 3   | 3                     |
| 60           |     |     |     |     |     |     |     |     |     | 1   | 2                     |
| number of trees, pcs | 6   | 4   | 3   | 4   | 5   | 11  | 3   | 2   | 3   | 5   | 44                    |

**Figure 1.** Timeline of the tree number according to height and diameter by thickness steps.

The seed productivity of yields in 2019 was estimated for trees and according to linear indicators of cones and seeds: length, width of a cone, length of a seed with a wing, length of a seed without a wing,
and width of a seed. The results of processing the material according to the morphometric parameters of cones and seeds are presented in Table 2.

**Table 2. Characteristics of Pseudotsuga menziesii (Mirb.) Franco cones and seeds (X±Sx).**

| Site          | Parameters        | tree No | length of cone, cm | width of cone, cm | length of seed with wing, cm | length of seed without wing, cm | width of seed, cm |
|---------------|-------------------|---------|--------------------|-------------------|-------------------------------|--------------------------------|------------------|
| Object 1      | P. menziesii, 33 years old | 1       | 6.00±0.07          | 2.60±0.03         | 0.72±0.006                    | 0.45±0.003                     | 0.37±0.003        |
|               |                   | 2       | 6.40±0.19          | 2.50±0.07         | 0.86±0.008                    | 0.44±0.005                     | 0.35±0.003        |
|               |                   | 3       | 6.50±0.10          | 2.60±0.10         | 0.89±0.011                    | 0.40±0.004                     | 0.30±0.004        |
|               |                   | 4       | 6.30±0.05          | 2.40±0.05         | 0.90±0.011                    | 0.46±0.003                     | 0.32±0.004        |
|               | Average           |         | 6.30±0.06          | 2.50±0.03         | 0.84±0.004                    | 0.44±0.002                     | 0.35±0.002        |
|               | P. menziesii, gray, 33 years old | 1       | 6.60±0.05          | 2.50±0.02         | 0.85±0.004                    | 0.45±0.002                     | 0.35±0.002        |
|               | Average           |         | 6.60±0.05          | 2.50±0.02         | 0.85±0.004                    | 0.45±0.002                     | 0.35±0.002        |
| Object 2      | P. menziesii, 30 - 40 years old | 1       | 4.59±0.20          | 2.34±0.10         | 1.01±0.01                     | 0.52±0.01                     | 0.29±0.01        |
|               |                   | 2       | 5.40±0.20          | 2.75±0.10         | 1.22±0.01                     | 0.64±0.01                     | 0.36±0.01        |
|               |                   | 3       | 6.21±0.30          | 3.12±0.10         | 1.37±0.01                     | 0.66±0.01                     | 0.30±0.01        |
|               |                   | 4       | 5.10±0.10          | 2.46±0.10         | 1.22±0.01                     | 0.64±0.01                     | 0.33±0.01        |
|               |                   | 5       | 5.02±0.10          | 3.16±0.10         | 1.31±0.01                     | 0.56±0.01                     | 0.31±0.01        |
|               |                   | 6       | 6.24±0.30          | 3.46±0.10         | 1.53±0.01                     | 0.60±0.01                     | 0.39±0.01        |
|               |                   | 7       | 5.63±0.10          | 3.19±0.10         | 1.33±0.01                     | 0.59±0.01                     | 0.34±0.01        |
|               |                   | 8       | 5.39±0.10          | 3.14±0.10         | 1.34±0.01                     | 0.54±0.01                     | 0.32±0.01        |
|               |                   | 9       | 4.79±0.10          | 2.78±0.10         | 1.39±0.01                     | 0.54±0.01                     | 0.3±0.01         |
|               | Average           |         | 5.37±0.20          | 2.93±0.10         | 1.30±0.01                     | 0.59±0.01                     | 0.33±0.01        |
| Object 3      | P. menziesii, 40 - 50 years old | 2       | 6.34±0.10          | 3.41±0.01         | 1.30±0.01                     | 0.59±0.01                     | 0.35±0.01        |
|               |                   | 3       | 4.80±0.20          | 3.37±0.01         | 1.36±0.01                     | 0.60±0.01                     | 0.34±0.01        |
|               |                   | 4       | 5.58±0.20          | 3.26±0.01         | 1.40±0.01                     | 0.58±0.01                     | 0.37±0.01        |
|               | Average           |         | 5.50±0.10          | 3.35±0.10         | 1.35±0.01                     | 0.59±0.01                     | 0.35±0.01        |
| Object 4      | P. menziesii, 40 - 50 years old | 1       | 7.75±0.30          | 3.53±0.20         | 1.77±0.10                     | 0.60±0.10                     | 0.43±0.10        |
|               |                   | 2       | 7.25±0.70          | 3.65±0.10         | 1.74±0.10                     | 0.62±0.10                     | 0.44±0.10        |
|               |                   | 3       | 6.63±0.50          | 3.45±0.30         | 1.75±0.10                     | 0.63±0.10                     | 0.35±0.10        |
|               |                   | 4       | 6.90±0.20          | 3.18±0.10         | 1.57±0.10                     | 0.63±0.10                     | 0.33±0.10        |
|               |                   | 5       | 7.04±0.50          | 3.38±0.10         | 1.74±0.10                     | 0.64±0.10                     | 0.38±0.10        |
|               |                   | 6       | 6.73±0.30          | 3.60±0.10         | 1.72±0.10                     | 0.67±0.10                     | 0.36±0.10        |
|               |                   | 7       | 6.15±0.40          | 3.15±0.10         | 1.31±0.10                     | 0.50±0.10                     | 0.33±0.10        |
|               |                   | 8       | 6.73±0.30          | 3.02±0.10         | 1.47±0.10                     | 0.56±0.10                     | 0.37±0.10        |
|               |                   | 9       | 6.30±0.30          | 2.75±0.10         | 1.50±0.10                     | 0.54±0.10                     | 0.37±0.10        |
|               | Average           |         | 6.85±0.20          | 3.29±0.10         | 1.64±0.10                     | 0.61±0.10                     | 0.37±0.10        |

Object 1 - planting of sixteen trees along the street of South Moravian. The condition of the trees varies from good to satisfactory. Trees No. 1 - 4, and No. 10-16 have a good condition - 1 category. Seeds were noted on four trees of P. menziesii, 25 years old, the number of cones varies from 250 to 500 pcs and on one tree P. menziesii, gray 33 years old, the number of cones is 350 pcs. Tree No. 5 -
dying off - 5 category, No. 6 - 2/3 of the crown dried up - very weakened, 3 category, No. 7,8,9 - weakened state - 2 category.

Object 2 - landing of the *P. menziesii* 30-40 years old of nine trees that grow along the highway. Soils - light gray forest sandy loam. Most of the trees are in good condition, some in the lower part of the crown have 2-3 dried branches. The number of cones varies depending on the productivity of the tree from 500 to more than 9000 pcs. At the tree number 1 sawn branches on the trunk at a height of 10 meters from the ground, due to the previously fallen power pole. Therefore, the number of cones is calculated only in the upper part of the crown - 3867 pieces. On the trees No. 1,5,8, the presence of atypical small cones is noted, which are located singly and in a cluster in the branches. The appearance of atypical small cones was noted for this object in 2018 [17].

Object 3 - planting on Lenin street from four trees, it grows in single plantings. Tree No. 1 - drying, the crown is very openwork; gray needles; growth is very weak, almost absent; drying out of more than 2/3 branches is noted - the 4th category of condition. It is located in close proximity to the highway, has a very small trunk circle, the root system is under the pavement, there is no soil aeration, which depresses the root system - the tree dies. Tree number 2 is located 5 meters from the road, the condition is assessed as very weakened - the openwork crown; needles are light green, matte; growth is weak, less than half the usual; branches are drying up to 2/3 of the crown - 3 category. In the upper and middle parts of the crown cones in the amount of 534 pcs. Trees No. 3 and No. 4 are maximally distant from the road - 40 meters. Trees grow alone, the soil around is not compacted. The trees are in good condition, without dry branches. In the crown there are from 5500 to 11500 pieces of cones. When examining crowns, mechanical damage and broken branches were noted, probably due to closely working construction equipment.

Object 4 – “Polytechnic” square - nine trees grow in groups of 2-3 trees with very close distribution, which causes the flag-shaped shape of the crown. The middle tier of crowns is openwork, with several dry branches of 3 to 5 or more, probably due to shading by neighboring trees (Tilia platyphyllos Scop., *Picea pungens* Engelm., *Ulmus carpinifolia* L., *Betula pendula* Roth). Soil conditions - bulk soil. Productivity is low, the number of cones ranges from 100 to 900 pcs. The condition of the trees is characterized as weakened - category 2 - flag-shaped crowns, the presence of dry branches, sparseness in the middle tier of the crown, possibly due to lack of light.

Object 5 - the square “named after F.E. Dzerzhinsky” - on the territory of the square there grows one *P. menziesii* tree in a single planting, 25-30 years old. The condition is weakened, the tree has a bifurcated trunk, is in close proximity to the road network. The crown is dense, without dry branches, the needles are green, there are no cones in the crown - status category 2.

The difference in yield in the number of cones in different trees of *P. menziesii* is explained by the fact that it is a monoecious species, as a rule, in the female type the seed-bearing layer occupies 80-90% of the crown, in the mixed type it is about 60%, in male - less than 30% [18]. The maximum number of cones is characteristic of female-type trees, the average is mixed and the minimum is male-type.

While comparing the linear signs of cones and seeds by objects (table 2), it was found that the average length of the cones varies from 5.37 to 6.85 cm, the maximum value of the sign was noted for the fourth object (6.85 cm), the minimum for the second and third objects (No. 2 - 5.37 cm and No. 3-5.50 cm), (Tₜ 4.47-4.96 at Tₓ=2.0 at P = 0.95). Intermediate values were noted for the trees *P. menziesii*, 25 years old - 6.3 cm and for *P. menziesii*, gray 33 years 6.6 cm in the first object. According to this criterion, the trees of object No. 1 and No. 4 do not differ significantly (Tₜ 0.7 - 1.29 at Tₓ=2.0 at P = 0.95).

The variability of the trait on the first and fourth objects varies at very low level (C.V = 3.5-6.4 - 7.2%), at the second - at a low (C.V = 10.8%). The variability of the length of the cone at the third object increases to an average level (C.V = 14.6%), this is possibly due to a reaction to the influence of vehicle emissions and a high anthropogenic load.

The average width of the cones varies from 2.5 to 3.35 cm. Cones of maximum width are observed in trees at the third and fourth objects (No. 3 - 3.35 cm and No. 4 - 3.29 cm, Tₜ 2.6 - 5.07 at Tₓ=2.0 at
P = 0.95). The minimum value of the trait is characteristic of the first - 2.5 and the second object - 2.93 cm. This indicator is more dependent on the genotype; therefore, the variability of the trait does not exceed a low level. In the first, third and fourth objects, the sign varies at a very low - low level (C.V. = 2.4 - 3.2-7.6%), in the second object the variability increases to an average level (C.V. = 12.6 %).

The length of the seed with a wing varies from 0.84 to 1.64 cm. The minimum values are characteristic of trees at the first object (0.84-0.85 cm). The maximum lengths for seeds with a wing are in trees at the fourth object (1.64 cm), an intermediate value of the indicator is observed in trees at the second and third objects (T<sub>r</sub> 4.74-10.07 at T<sub>r</sub>2.0 at P = 0.95). This trait is more stable and varies at a very low level in trees at the first object (C.V. = 7.1 - 8.3%), at a low level at the second, third and fourth objects (C.V. = 9.3-10.8%).

The length of seeds without a wing does not differ significantly in objects, the average indicators vary from 0.44 - 0.61 cm. The trait varies at a very low level in trees at the first object (C.V. = 4.4-4.5%). At the second, third and fourth objects, the variability increases to a low level (C.V. = 10.2-11.9%).

The average seed widths do not significantly differ between objects and vary from 0.33 to 0.37 cm. But this trait turned out to be the most variable. At a low level (C.V. = 8.6%), the trait varies at facility No. 1 in the P. menziesii trees, gray 33 years and (C.V. = 11.4%) in the P. menziesii trees, 25 years old. The variability of the trait at the second, third and fourth objects (C.V. = 13.2-15.2%) increases to an average level.

According to the correlation analysis at the first object, the dependence of the length and width of the cone is weak (r = 0.15), the length of the seed without a wing also weakly depends on the length of the seed with the wing and on the width of the seed (r = 0.02-0.16). This is probably due to the younger age of the trees (25 years). In plantations, Pseudotsuga puberty occurs from 20-30 years old [12]. The second object shows a strong positive relationship between the length and width of the cone (r = 0.74), the length of the seed without a wing weakly depends on the total length of the seed with the wing and on the width (r = 0.11-0.37). At the third object and the fourth object, the dependence of the length and width of the cone has an average positive character (r = 0.57-0.66). The nature of the dependence of these objects along the length of the seed without a wing differs from the length of the seed with a wing. At the third object, it is weak (r = 0.14). The width of the seed has an average positive relationship with the length of the seed with the wing and with the length of the seed without the wing (r = 0.54-0.61). At the fourth object, the dependence of the length and width of the cone is average positive (r = 0.66). The dependence of the length of the seed with the wing and without the wing (r = 0.61) is average positive and the length of the seed weakly depends on the width (r = 0.17-0.29). Thus, in three of the four objects, an average and strong positive correlation was observed between the length and width of the cone; the average length and width of the seeds correlate with the average positive force, which is observed in the third and fourth objects. Trees at these sites have a higher age of 40-50 years and are in the steady generative period of ontogenesis.

4. Summary
Increased polymorphism and the level of variability of the organs of the vegetative and generative spheres of introducers can be observed under the influence of growth conditions not typical for the species, as well as under the synergistic effect of factors of the urban environment. The levels of endogenous variability of the structural signs of cones in trees at different objects are established. Linear signs of cones (length and width) on the first and fourth objects vary at a very low and low level. The variability of traits increases to an average level at the second and third objects, which are located in close proximity to roads. Linear parameters of seeds (seed length with wing, seed length without wing, seed width) at the first object in P. menziesii trees, 25 years vary at a very low and low level, in P. menziesii trees, gray 33 years variability remains at a very low and low level. At the second object, in P. menziesii trees, 30-40 years old, the length of the seed with or without a wing varies at a low level, and the variability of the width of the seed increases to medium. The same pattern was
observed for *P. menziesii* trees, 40-50 years old at the third facility and fourth facility. The data obtained, as a rule, correspond to the characteristics of the individual variability of conifers in natural stands established by S. A. Mamaev [16].

In urban environments, the level of endogenous variability of morphometric traits of cones and seeds rises more in trees at sites no. 2,3,4 and slightly weaker at facility 1. The negative impact of vehicle emissions is reflected in the satisfactory and poor condition of trees growing in close proximity to the road, with compacted soil, or the absence of an under-trunk circle under the trees. At facility No. 4, an increase in the level of variation of traits is also affected by shadowing by neighboring trees. In relation to light, *Pseudotsuga* is moderately shade-tolerant, but more demanding than fir and spruce; it does not tolerate shading [12]. Therefore, to collect seeds, you need to choose trees in a good category of condition, away from roads, in group plantings, because when solitary, the risk of self-pollination and the formation of empty seeds increases.

The mass reproduction of the *Pseudotsuga* in the conditions of the central forest-steppe is restrained due to the lack of mother plants and the method of effective cultivation. For successful introduction, the question of the origin of planting material is important. This is due to the significant diversity of climatic and soil conditions within the natural range. *P. menziesii* is promising for mass introduction into forest crops, resistant to changes in air temperature. This is the main forestry species, which is currently widespread in the European part of Russia. *P. menziesii* manifests itself as a very labile breed mixed with local forest species, which determines the possibility of its widespread distribution in artificial phytocenoses, where greater stability and longevity of this breed can manifest itself [6]. Thus, the occurrence of *P. menziesii* in common stands is insufficient, which requires extensive implementation. As a practical recommendation, it is possible to advise the city administration to improve the microclimate and ecosystem services of parklands to increase the species composition of conifers in the city’s green spaces. The parks, squares, boulevards are an important element of urban development, a factor of great importance in the sanitary-hygienic, architectural, planning and social relations. In the formation of urban green spaces, it is necessary to have comprehensive information about the qualitative and quantitative status of plants, to preserve the species of local flora, like islands of natural vegetation in order to preserve the natural specifics of the region, it is also necessary to introduce new species in order to increase biodiversity. And in this case, introduced species require control over its distribution, interaction with local plants, diseases; adequately assess the anthropogenic impact on all components of cultural phytocenosis. Therefore, in the future we plan to conduct long-term monitoring of the state of these facilities, which will allow these landscapes to be preserved for the townspeople.

The analysis of the variability of the biometric parameters of cones and seeds is also of great importance, since it is controlled by many genes and have a high reaction rate. Variability was evaluated within cultural phytocenoses, therefore, at this level, variability is weakly expressed than that of individual trees at the endogenous level [16, 17]. In this regard, for the selection of resistant species and forms, a deeper study of the polymorphism of cones and seeds is necessary to identify correlative traits associated with tree productivity indices.

References:

[1] Zalesova E S, Zalesov S V, Bunkova N P, Kletsko N P, Solovieva M V and Krekova Y A 2019 Forest science in the implementation of the concept of the Ural engineering school: socio-economic and environmental problems of the forest sector of the economy Proc. of the XII Int. Scientific and Technical Conf. “Promising coniferous introducers for landscaping and expanding biological diversity in the middle Urals”. Ministry of Science and Higher Education of the Russian Federation (Ekaterinburg, Ural State Forestry University) 169-172

[2] Klein T 2020 A race to the unknown: Contemporary research on tree and forest drought resistance, an Israeli perspective *Journal of Arid Environments* 172 104045 doi.org/10.1016/j.jaridenv.2019.104045

[3] Egerer M, Ordóñez C, Lin B B and Kendal D 2019 Multicultural gardeners and park users
benefit from and attach diverse values to urban nature spaces "Urban Forestry & Urban Greening" 46 126445 doi.org/10.1016/j.ufug.2019.126445

[4] Lew A, von Aderkas P, Berland A, Curry C L, Lacourse T, Tencer B and Weaver A 2017 An assessment of Pinus contorta seed production in British Columbia: Geographic variation and dynamically-downscaled climate correlates from the Canadian Regional Climate Model "Agricultural and Forest Meteorology" 236 194-210 doi.org/10.1016/j.agrformet.2016.12.013

[5] Chugreev M Yu and Starodubtseva L M 2017 Modern forest science: Problems and prospects Proc. of the All-Russian Scientific and Practical Conf. 281-285

[6] Rusin N S, Gorevalova S Yu, Shiryaev V I 2012 Growth and status of introductory origins (forms) of the Pseudotsuga menziesii in the Central Forest - Steppe Assessment, Conservation and Sustainable Use of Plant Biological Diversity (Proceedings of the International Conference dedicated to the 80th anniversary of the Central Botanical Garden of the National Academy of Sciences of Belarus) (June 19-22 2012 Minsk Belarus) part 2 p 170-174

[7] Mayr H 1908 Die Naturgesetzlicher Grandlage des Weldbauses (Berlin) p 57

[8] Pavari A 1916 Studio preliminary sully culture dei special forestall esotiche in Italia (Pirenze) p 83

[9] Selyaninov G T 1928-1929 Proc.: Applied botany, genetics, selection Climatic analogues of the Black Sea coast of the Caucasus 21 57-73

[10] Hutton E M 1974 Plenary Papers XII Intern Grasmed. Congr. (Moscow) pp 1-25

[11] Belyuchenko I S and Mustafayev B A 2013 Plant introduction as a method of expanding the species composition of cultivated phytocenoses in the southern regions of the CIS Ecological Bulletin of the North Caucasus 9 (4) 73-89 http://ecokavkaz.ru/media/docs/2013/4/2013-4-6.pdf

[12] Pchelin V I 2007 Dendrology: textbook (Yoshkar-Ola: Mari State Technical University) p 520

[13] Koropachinsky I Yu, Vstovskaya T N and Tomoshevich M A 2011 Immediate tasks of the introduction of woody plants in Asian Russia "Siberian Journal of Ecology" 2 147-170

[14] Decree of the Government of the Russian Federation of 05.20.2017 N 607 “On the Rules of Sanitary Safety in Forests” http://www.consultant.ru/document/cons_doc_LAW_217315/

[15] Korchagin A A 1960 Methods of recording the seeding of tree species and forest communities. Field geobotany Vol 2 (Moscow, Leningrad: Publishing house of the USSR Academy of Sciences) 41-162

[16] Mamaev S A 1973 Forms of Intraspecific Variability of Woody Plants (on the Example of the Pinaceae Family) (Moscow: Nauka Publishing) p 284

[17] Chekmeneva Yu V, Tkachev V V and Krasnov V G 2018 Phenotypic variation of generative signs of different reproductive types of Pseudotsuga menziesii (Mirb.) Franco in urban environment (in the forest-steppe zone) IOP Conf. Ser.: Earth Environ. Sci. 226 012050 doi:10.1088/1755-1315/226/1/012050

[18] Babich N A and Khamitov R S 2018 Growth of seedlings of siberian stone pine in tree breeding of different reproduction types Lesnoy Zhurnal [Forestry journal] 1 29-36 doi: 10.17238/issn0536-1036.2018.1.29