Estimation of ecological resistance of forests around the Territory of the Vladivostok City agglomeration

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Abstract. The article contains the data based on the results of studies into the forests of the green-zone urbanized areas of cities within the Vladivostok City Agglomeration. It demonstrates the distribution of forest-covered areas according to cities and age classes as per the territory under study. The territory under study was analyzed in terms of the distribution of forest-covered areas into various degrees of resistance found in the planted vegetation.

1. Introduction
Currently, the Russian Federation employs a well-defined state policy on the acceleration of economic growth across Far East and Cisbaikalia supported by considerable funding and stipulated by the regulation "Strategy for the Development of Far East and Baikal Region until 2025". One of key points of the Strategy lies with the implementation of the Great Vladivostok Project: all around the territory of Vladivostok within the bounds of the system of towns that are to form into the Vladivostok City Agglomeration (Artem, Bolshoy Kamen, Nakhodka, Ussuriysk, Partizansk) there is an industrial belt emerging, which requires reasonably designed green zones in each of the towns (Figure 1).

Using forest areas for various purposes, including recreational, requires specifically developed estimation methods, arrangement of necessary works broken down into three main phases: development of a scientifically feasible procedure for estimating forest resources, its practical evaluation through a case-study, unselected estimation of all forestry lands with similar functions, and, importantly, determination of ecological resistance of planted vegetation [1]. Today, the territory of Primorsky Territory is dominated by valley-growing broadleaved forests (27%), ash forests (16%), oak woods, or oak groves of various genetic origins (50-60%) [2, 3].

2. Materials and methods
The green zones attributed to the Vladivostok City Agglomeration belong to the Vladivostok Forestry Department that is part of the Primorsky Forestry Regional State Public Institution and itself is its autonomous structural division, its branch.

The boundaries of the forestry department are set forth by the Federal Forestry Agency in Decree No. 313 On the Definition of the Number of Forestries in Primorsky Territory and their Demarcation dated June 29, 2017. In compliance with the current forest management instruction, the green-zone forests are being estimated in terms of resistance, aesthetics, sanitation and hygienics, and landscape design [4, 5]. Such estimates of the green-zone forests within the bounds of the Vladivostok City Agglomeration were made based on a rather representative data selection.
There were 34 pilot areas set out around the green zone of the Vladivostok City Agglomeration following the procedure designed by I. A. Pavlenko; the main species were surveyed to define the degree of resistance demonstrated by the planted vegetation [6].

3. Research results
Within the limits of the Vladivostok Forestry Department, there are over 60 species of trees, of which 20 can form areas of planted vegetation with their prevalence.

The main types of forest species in Regional state government institution "Primorsky lesnichestvo" are Pine (Pinus sylvestris L.), Korean pine (Pinus koraiensis Sieb. et Zucc.), Ayan and Korean spruce (Picea ajanensis Lindl. et Gord., P. Koraiensis Nakai), White fir (Abies nephrolepis (Trautv.) Maxim.); hard-leaved species: Mongolian oak (Quercus mongolica Fisch. ex Ledeb.), Notched oak (Quercus dentata Thunb.), Manchurian ash (Fraxinus mandshurica Rupr.), Nasal leaf ash (Fraxinus rhynphylla Hance), Japanese elm (U. japonica (Rehd.) Sarg.), Lobed elm (U. laciniata (Trautv.) Mayer), etc., River maple (Acer ginnala Maxim.), False-banded maple (Acer pseudosieboldianum (Pax.) Kom.); soft-leaved species: Daurian birch (B. davurica Pall.), Yellow birch (Betula costata Trautv.) and others, aspen (Populus tremula L.) and other tree species.

Largely, these are represented by broadleaved species, among which Mongolian oak is most dominant in terms of the area covered (table 1). Currently, the southern parts of Far East are marked by increasingly soft-leaved species that cover significant areas of the land (the urban districts of Vladivostok, Ussuriysk and Artem). The forest-covered area of the territory under study is unevenly spread in terms of the main species and age classes (table 1).

As we can be see from the Table 1, the hard-leaved species occupy the most part of the territory - 95.4%, where oak occupies 86.3% and linden occupies 4.6%.

Concerning the soft-leaved species, the largest area in the forested territory is occupied by birch plantations - 2.8%.

Taking into consideration age classes, the largest area is occupied by middle-aged trees, it takes 65.4%, the smallest is occupied by young growths – 1.8%, and ripening trees occupy about 30.2% of the area covered by forest vegetation.

Resistance of planted vegetation is defined as its ability to withstand the adverse effects of the environment that cause premature withering of plants, and grow sustainably across its territory of prevalence [7].

Table 1. Distribution of forest-covered areas as per species and age classes across the territory under study.
### Table 2. Distribution of the forest-covered areas across the territory under study as per degrees of resistance shown by the planted vegetation, ha.

| Species        | Degree of resistance, ha | Total, ha |
|----------------|--------------------------|-----------|
|                | I | II | III | IV | V  | VI | Total, ha       |
| Coniferous     |   |   |     |    |    |    |                  |
| Fir            |   |   |     |    |    |    | 1.2              |
| Oak            | 7.1| 10.5| 543.8| 851.2| 449.5| 52.4| 69.7| 1914.5| 86.3 |
| Linden         |   |   |     |    |    |    | 2.8             |
| Ash            |   |   |     |    |    |    | 19.8            |
| Walnut tree    |   |   |     |    |    |    | 16.3            |
| Hard-wooded broadleaved |   | 15.2| 14.6| 28.9| 74.0| 52.2| 65.8| 102.9| 4.6 |
| Soft-leaved    |   |   |     |    |    |    | 5.2             |
| Birch          |   |   | 10.2| 46.3| -   | -   | 31.3| 63.2| 2.8 |
| Alder          | 1.1|   | -   | -   | 10.1| 14.8| 49  | 26  | 1.2 |
| Aspen          |   |   | -   | -   | -   | 10.5| 45  | 10.5| 0.5 |
| Total          | 8.2| 32.4| 573.8| 933.6| 518.4| 152.9|       | 2219.3| 100 |

The degree of resistance found in planted vegetation depends on the indicators of resilience and gas resistance. The resilience of planted vegetation is defined by the overall condition of forest stand, particulars of its growth, and the signs of tree drying [8, 9]. The forest management system uses a three-grade estimation technique:

- **First Degree** (good mark) characterizes absolutely healthy vegetation that manifests good growth and development of new growth and shrub layer typical of this forest; the trees of normal height account to 70% for broadleaved species and 90% for coniferous species.

- **Second Degree** (satisfactory mark) characterizes healthy vegetation marked by retarded growth and slow development, indented tree crown in some of the trees, pale green of needles or leaves as a result of short-term exposure to one of the unfavorable factors that are easy to prevent; there is no new growth or it is futile; the shrub layer and undergrowth above the soil are to a great extent trampled down, the soil is compacted; the trees of normal height make up 51-70% among the broadleaved species and 71-90% among the coniferous species.

- **Third Degree** (poor mark) characterizes vegetation marked by retarded or absent growth and development caused by a number of adverse factors; there is no new growth; the shrub layer and undergrowth are trampled down completely; the soil is compacted to a greater extent; many trees bear signs of mechanical damage or infestation and disease; the trees of normal height comprise 31-50% among the broadleaved species, and 51-70% among the coniferous vegetation; the planted vegetation normally requires felling [10].
The system used by forestry management to evaluate resistance of planted vegetation is often arbitrary. Sometimes it may make sense to apply 4 degrees. Table 2 shows that vegetation with the 4th degree of resistance cover only 14.1 ha. The identification was carried out based on the properties that correlate with the vegetation resistance of 4th degree according to M. I. Galperin [11]: "4th degree characterizes planted vegetation with signs of obvious decay, no chance of revitalization; healthy trees make up less than 20%" (p. 131).

Although stability assessment was not carried out in all forest districts of the green zone of the Vladivostok City Agglomeration, the available materials allow us to conclude that the plantings here are quite flexible and able to withstand significant external influences they have a large natural margin of safety. All this allows plantations to be preserved and exist in time in the form of ecosystems.

4. Conclusion
Even though the resistance estimation was only carried out in certain forestry within the green zone, the collected data are sufficient to conclude that the planted vegetation in that area is quite flexible, able to resist considerable external impact and has a high natural margin of strength. It allows the planted vegetation to persevere and exist in time as ecosystems. Forest ecosystems deteriorate under the recreational pressure up to a point of total degradation with further transition to a different qualitative state. Recreational degradation spreads unevenly across the area, peaking around trails, organized parking lots and other places with intense visitor traffic.

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