Oak forests in reserves of the Far East

Valentina Ostroshenko*

Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch of the Russian Academy of Sciences, 159, prosp. 100 years of Vladivostok, Vladivostok, 690022, Russia

Abstract. Oak is one of the most important woody plants in the Far East. It is of great national economic importance. The article is devoted to the study of species diversity, as well as the distribution of the oak area and its stock in the Far East in the period 2016-2023. The work is based on the analysis of the sources of literature and forest inventory materials on the topic of research. Within the Far East, there are four species of the genus *Quercus*, namely: Mongolian oak (*Quercus mongolica* Fisch. Ex Turcz.), Japanese emperor oak (*Q. dentata* Thunb.), mizunara (*Q. crispula* Blume) and Quercus wutaishanica Mayr (*Q. wutaishanica* Mayr.). It was found that over the last 7 years the area of oak distribution in the region, especially in Primorsky Territory, has decreased. This is due to forest fires, illegal cutting of timber. One of the ways in which it can be restored can be the use of growth stimulants in forest nurseries when growing seedlings. Sowing of oak acorns under the forest canopy, in burned areas, clearings, as well as wastelands and areas not covered with forest vegetation is possible with the help of a manual cane seeder.

1 Introduction

Oak is one of the most important woody covered plants of the Russian Far East. It occupies an area of about 3.5 million ha [1]. The role of oak in the natural reproduction process can be called one of the main indicators characterising the productivity of forest ecosystems [2].

The oak tree does not require soil type and can grow both on fresh and dry deep soils of foothills and on mountain slopes. Most often it grows on southern slopes, tops of hills, with fine crushed stone or stony, brown mountain-forest, coarse-humus, ogleen soil with leaching moisture and good drainage. Closer to the north-east, the trees are low-barked [3].

There are three main types of oak forests in the Far East: mountain rhododendron-lespedeceous, mountain hazel and mountain shrub forests. Mountain rhododendron-lespedeceous oak forests combine mountain lespedeceous, rhododendron-osier, fine-sedge, herbaceous, sparse-blooded, high-mountain forest types with lingonberry.

Mountain hazel oak forests consist of such forest types as hazel park forest, hazel-lespedeceous forest, hazel-hemlock forest, fern-variegated shrub forest, mixed herb forest with black birch and ash. Mountain shrubby oak forests include the following forest types: shrubby with maple, rhododendron-shrubby with maple, lespedeza-shrubby with maple, with linden and Manchurian hazel [4].

* Corresponding author: OstroshenkoV@mail.ru

In the Far East, oak grows mainly in Primorsky Territory, Khabarovsk Territory, Amur and Sakhalin Regions, and the Jewish Autonomous Region (Figure 1).

Fig. 1. Distribution area of the genus Oak in the Far East.

Oak has a great national economic significance [5]. Oak is effectively used in the reclamation of agricultural land, as well as in the creation of protective forest plantations along motorways and railway tracks. S.P. Kuznetsov noted that it is better to use it to create an impervious structure due to the fact that it sheds its leaves not completely in winter, although it cannot be recommended for all cases [6]. The forage base of oak forests includes a variety of plants, which favourably affects the diet of animals. For some animal species, this forage base is a priority [7-8]. Acorns are used to make coffee. Leaves are used in pickling. Oak wood is used in shipbuilding, wagon building, agricultural machinery production, construction of underwater structures, interior decoration of premises. Oak wood is used for parquet, furniture, barrels, planed and peeled veneer and glued plywood. After steaming, it bends well and has good strength, so it is used for crafts. Through chemical processing, wood can be used to produce wine and wood alcohol, carbon dioxide, cellulose, acetic acid, fodder yeast, carton, furfural, and charcoal. The resilient and strong trees are used to make hoops [3].

This study examined the species diversity of oak in the Far East, its distribution area and total stock from 2016 to 2023.

2 Materials and methods

In this study, we used a qualitative research method, namely the analysis of literature sources on the research topic. Articles constituting a representative sample of international scientific activity published in scientific journals were analyzed. In the third section of the article, we have identified species of the genus Oak, growing in the Far East in various forest conditions. We have given a description of their distribution, the main ecological and biological features and conducted their comparison.

Also in this section of the article, an analysis of forest inventory materials is carried out in terms of the area and stock of Oak plantations in the regions of the Far East in the period from 2016 to 2023. A discussion of the data obtained is given, and possible measures for the restoration of the Oak in the Far East, especially in the Primorsky Territory were proposed.

3 Results and discussion

The genus *Quercus* in a broad sense is a representative of the family *Fagaceae*. It also includes the genus *Fagus*, but in the Far East it is represented by a single genus, Oak.

The genus *Quercus* first appears in the fossil record of the Far East during the late Pleistocene. The authors noted that the apparent appearance of Oak in the Early Pleistocene epoch in the Far East (in Primorye) (Sobolevka, Avgustovka) refers only to the genus, as evidenced by the study of its leaves, as well as pollen [9].

Four species of the genus *Quercus* are distinguished in the Far East: Mongolian oak (*Quercus mongolica* Fisch. Ex Turcz.), Japanese emperor oak (*Q. dentata* Thunb.), chick oak (*Q. crispula* Blume) and Quercus wutaishanica Mayr (*Q. wutaishanica* Mayr.).

The distribution area of Mongolian oak is mainly Primorsky and Khabarovsk Territories, Amur Region (Zeya Reserve), as well as the eastern coast of Nikolai Bay in Nikolayevsky District of Khabarovsk Territory [3]. This species is an important component of mixed forests of the Russian Far East [5]. In the southern areas, it rises up to 700-800 and sometimes up to 1 km into the mountains [3]. It is of great economic importance [5]. Authors note its good stability after fires [10]. Mongolian oak is ornamental. It is used in alleys, group plantings for protective forest belts, non-renewed woodlots, as well as restoration of abandoned territories [3].

The Japanese emperor oak grows in the south of Khasansky District, on the slopes of Chaydashan in Partizansky District, in the vicinity of Suchan and somewhat to the north, near Nakhodka, as well as in the area of the Suzukhe River. It has mountain and soil protection value. Due to its small distribution, it has no industrial significance. It is included in the Red Books of Primorsky Territory and Sakhalin Region [2]. The authors note that the appearance of Mongolian and Japanese emperor oak in the Far East is associated with the Late Halocene epoch [11-14].

Mizunara, on the contrary, prefers colder climates. Thus, it is found in the south of Sakhalin and in the southern part of the Kuril Islands (Iturup and Kunashir). Unlike Mongolian oak, it grows on lower slopes. Usually between 15-20 and 200-220 metres above sea level. It forms natural hybrids with Mongolian oak in places of pro-growth. Due to limited timber reserves and comparatively less valuable qualities, it has no industrial value compared to Mongolian oak [3].

Quercus wutaishanica Mayr is only found in the south of Primorsky Territory. It is decorative. It has anti-erosion value [2].

The above species bloom from May to June. They belong to deciduous species, but leaves of Mongolian oak fall only in spring.

Under favourable growing conditions, the Mongolian oak can reach a height of 30 m. In northern coastal and mountainous areas, its height rarely exceeds 10-12 metres. The trunks of young oaks are covered with smooth bark with a "mirror-like" surface, while the trunks of old specimens have thick bark covered with cracks. The leaves of Mongolian oak have a deep lobed, oblong shape [3]. They are similar to the leaves of European oak, but larger in size (30×17). This is probably due to the process of hybridisation. Thus, analyses of genome evolution showed that Mongolian oak has a close resemblance to *Q. robur*, and they share a common ancestor that was 11. 8 million years ago [15]. However, according to Pakhomov's research, the Mongolian oak wood is not only as good as that of the petiole oak, but also superior in mechanical properties. The acorns are almost sessile, ovoid in shape, with hemisphere-shaped plescae, lightly covered with down. Acorns are 1.5 cm long and 1.3 cm thick [3].

The height of the Japanese emperor oak is 20-25 metres. The trunk is covered with thick cracked bark. The leaves of the Japanese emperor oak are dense, obovate in shape, tapering at the base. They have broad short lobes divided into notches of small depth and small weakly

expressed ears. The upper side of the leaves is dark green in colour and almost bare, while the underside of the leaves is densely pubescent with stellate hairs. In shape, the leaves of the Japanese emperor oak resemble those of the petiole oak, but they are larger in size than the other three species. The leaves vary in length from 10 to 20 cm and in width from 7 to 12 cm. In scion trees, the leaves are 30 to 50 cm long and 20 to 30 cm wide. Acorns are hemispherical in shape, growing up to 2 cm in diameter. The acorns also have hemispherical form with a large number of leaflets with loose ends covered with dense pubescence. The species is similar to Mongolian oak in wood quality [3].

Mizunara has a height of 15 m and a trunk diameter of up to 70 cm. The leaves are dense, elliptic in shape, have sharp lobes with 1-2 teeth and laminae up to 20 cm, acuminate at the top and wedge-shaped at the base. The surface of the leaves is smooth, the underside is pubescent with stellate hairs. The acorns are about 1.5-2 cm long and 1.3 cm wide. The plica has keeled, tightly appressed scales that do not protrude below the edge. The shape of the plica scales of the Curmudgeon Oak is similar to the plica scales of the Mongolian Oak. But unlike the latter, the Curmudgeonly Oak sheds all its leaves in autumn [3].

Quercus wutaishanica Mayr is a small tree, up to 5 metres high. In contrast, the leaves of the species in question are small, from 6 to 8 cm. The number of lateral veins is from 6 to 9. The plica has flattened petioles. Mature acorns have a spherical shape and a diameter of no more than 1.3 cm [2].

Table 1 presents the forest fund data for the regions of the Far East where oak is the predominant tree species. Table 1 and Table 2 show the distribution area and stock of four oak species according to the forest inventory data for 2016 and 2023 (Table 1, 2).

Table 1. Oak distribution area in thousand hectares in the Far East.

Region	**Year**	
	2016	**2023**
Amur Region	405.2	405.3
Jewish Autonomous Region	342.0	341.2
Primorsky Territory	2 127.9	983.8
Sakhalin Region	25.1	24.9
Khabarovsk Territory	328.8	326.2
Totally	3 263.0	2 081.4

Table 2. Total oak stock in million m^3 in the Far East.

Region	**Year**	
	2016	**2023**
Amur Region	20.3	20.3
Jewish Autonomous Region	31.7	31.6
Primorsky Territory	231.2	266.1
Sakhalin Region	2.5	2.4
Khabarovsk Territory	34.0	38.5
Totally	319.7	358.9

According to the above data, it was noted that the area of oak distribution in Primorsky Territory in this period, compared to 2016, has significantly decreased (2.2 times). Reduction of oak distribution area is also observed in Khabarovsk Territory, Sakhalin Region and Jewish Autonomous Region. This is due to logging and forest fires. In contrast, the Amur Region shows an increase in the area occupied by oak forests. This can probably be explained by the ongoing reforestation activities.

At the same time, the total stock of oak in Primorsky and Khabarovsk Territory has increased over the last 7 years. This is probably due to higher growth of stand height and trunk diameter, which can be explained by favourable soil and climatic conditions. In the

other subjects of the Territory the stand stock is at the same level or its insignificant decrease is observed.

This is clearly illustrated in the graphs (Figure 2, 3).

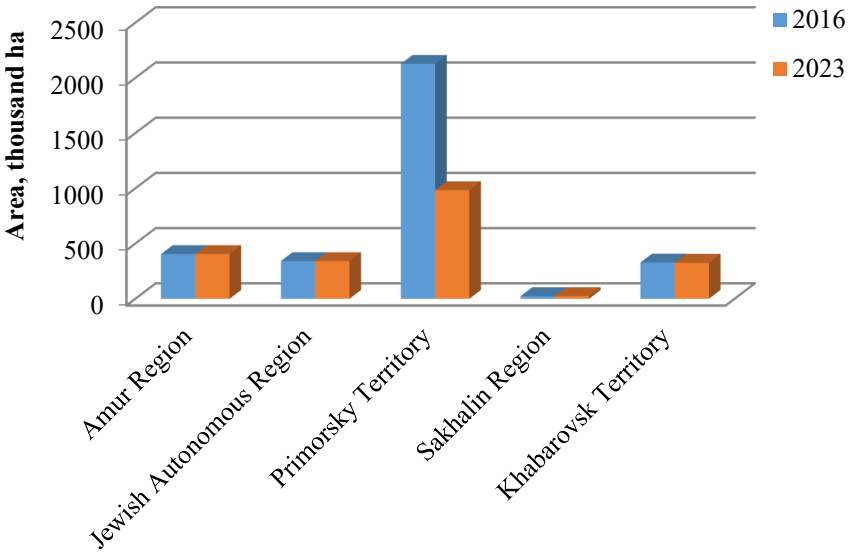

Fig. 2. Area of oak distribution in the Far East, thousand ha.

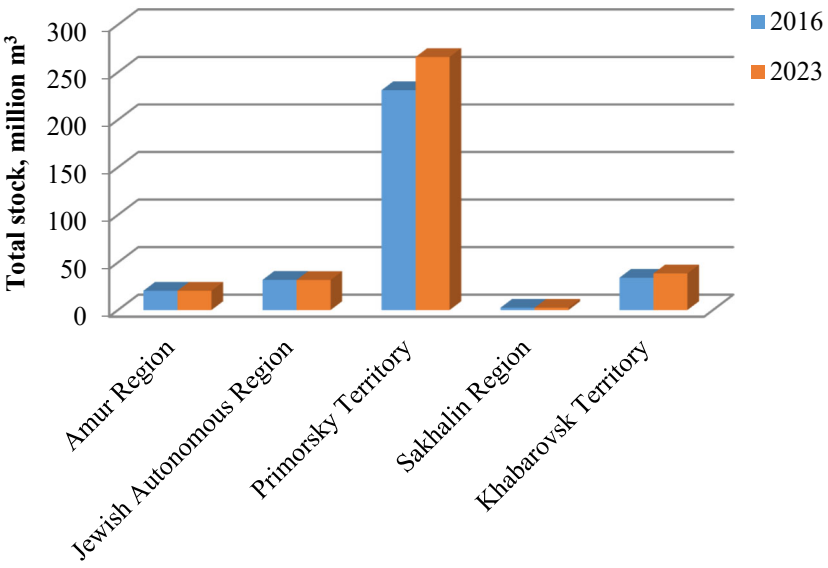

Fig. 3. Total stock of oak in the Far East, million m^3.

Thus, there is a decrease in the area of oak forests in the region, especially in Primorsky Territory. This is explained by forest fires and logging, which is also confirmed in the works of other authors [16].

Currently, this problem is proposed to be solved by creating oak forest plantations with the use of forestry machines and tools [16]. However, the disadvantage of such a method in the Far East region for all types of crops is a large amount of combustible materials with high flammability, namely: grass fall, which quickly dries out and easily catches fire, as well as high-calorie tree and shrub fall (leaves, needles). During the drought season, this can cause crop death by fire and severely disrupt the ecology. In addition, plantation crops are characterised by high cost [17].

One of the successful ways to accelerate oak regeneration in the Far East can be the cultivation of its planting material in forest nurseries with the use of growth stimulants. Thus, in forestry, stimulants have been actively used in recent years in the cultivation of various tree species [18-25]. Seedlings and saplings increase biometric indicators: height, root neck diameter, root system. Such indicators as safety, survival rate, frost and drought resistance increase.

Also, in the conditions of the Far East when planting forest crops under the forest canopy, on garlands, clearings, as well as wastelands, uncovered areas with forest vegetation when sowing oak acorns it is possible to use a hand seeder, designed by us at the Department of Forest Crops in Primorsky State Agrarian-Technological University. The developed seeder has a cane shape and can hold up to 3 kg of seeds. The weight of the seeder is about 2.8 kg. The seeder includes a hopper, seeding unit housing, metering unit, control handle, seed pipe, pedal and coulter. Despite the simplicity of this device, it has high efficiency and allows you to accurately sow acorns to a depth of up to 4 cm in the rows and inter-rows of forestry and agricultural fund. The seeder provides uniform seeding, which does not require additional preparation. Use of the device reduces the operator's workload, which increases the work productivity [26].

4 Conclusion

Thus, four species of the genus *Quercus* are identified within the Far Eastern region: Mongolian oak, Japanese emperor oak, mizunara, and Quercus wutaishanica Mayr. In 2023, the area of oak distribution was found to decrease compared to 2016, especially in the Primorsky territory. This is explained by forest fires, illegal timber felling.

One of the ways of its restoration may be the use of growth stimulants in forest nurseries for accelerated growth of planting material. Sowing of oak acorns under the forest canopy, in burned areas, clearings, as well as wastelands and areas not covered with forest vegetation is possible with the use of a manual cane seeder, which can provide increased reliability and productivity of sowing acorns.

The research was carried out within the state assignment of Ministry of Science and Higher Education of the Russian Federation (theme No. 124012200183-8).

References

1. H. Schröder, Y. Yanbaev, B. Kersten, B. Degen, Silvae Genetica **68(1)**, 85-91 (2019). https://doi.org/10.2478/sg-2019-0016
2. A.V. Seredyuk, N.V. Vyvodsev, Scientists notes PNU **7(4-1)**, 427-435 (2016)
3. N.V. Usenko, *Trees, shrubs and vines of the Far East* (Knizhnoe Publishing house, Khabarovsk, 1969)

4. G.V. Gukov, *Forest science* (Publishing house Dal'nauka, Vladivostok, 2014)
5. O. Krankina, R.L. Ethington, Forest products journal **45(10)**, 44 (1995)
6. S.P. Kuznetsov, Economic life of the Far East **8(9)**, 55-58 (1926)
7. S.P. Kucherenko, Use and reproduction of forest resources in the Far East **1**, 184-186 (1972)
8. M.V Podushko, *Nature conservation complexes of the Far East. Typological features and environmental regimes* (DVNTs AN SSSR, Vladivostok, 1984)
9. E. Barrón, A. Averyanova, Z. Kvaček, A. Momohara, Oaks physiological ecology. Exploring the functional diversity of genus Quercus L. **7**, 39-105 (2017). https://doi.org/10.1007/978-3-319-69099-5_3
10. M. Kobayashi, Y.P. Nemilostiv, O.A. Zyryanova, Eurasian Journal of Forest Research **10(1)**, 51-58 (2007)
11. P.S. Belyanin, P.M. Anderson, N.I. Belyanina, A. Lozhkin, Bulletin of the Russian Academy of Sciences: Geographic **2**, 69-84 (2019). https://doi.org/10.31857/S2587-55662019269-84
12. P.S. Belyanin, N.I. Belyanina, IOP Conf. Series: Earth and Environmental Science. **438**, 012003 (2020). https://doi.org/10.1088/1755-1315/438/1/012003
13. P. Belyanin, N. Belyanin, Limnology and Freshwater Biology **4** (2020). https: //doi.org/10.31951/2658-3518-2020-A-4-593
14. Yu. Shao-Hua et al., Quaternary International **432(A)**, 79-92 (2017). https://doi.org/10.1016/j.quaint.2014.07.059
15. W. Ai et al., Molecular Ecology Resources **22(6)**, 2396-2410 (2022). https://doi.org/10.1111/1755-0998.13616
16. A. Komin, V. Usov, A. Shcherbakov, Lecture Notes in Networks and Systems **574**, 2574-2583 (2022). https://doi.org/10.1007/978-3-031-21432-5_283
17. A.P. Kovalev, M.A. Sheshukov, V.V.Pozdnyakova, Forestry journal **3**, 77-83 (2018). https://doi.org/10.17238/issn0536-1036.2018.3.77
18. A.V. Egorova, N.P. Chernibrovkina, E.V. Robonen, Chemistry of Plant Raw Material **2**,171-180 (2017). https://doi.org/10.14258/jcprm.2017021720
19. V.Y. Ostroshenko, L.Y. Ostroshenko, Advances in current natural sciences **4**, 41-47 (2020). https://doi.org/10.17513/use.37360
20. V. Ostroshenko, L. Ostroshenko, Lecture Notes in Networks and Systems **353**, 637-647 (2022). https://doi.org/10.1007/978-3-030-91402-8_71
21. S.A. Kabanova, M.A. Danchenko, I.S. Kochegarov, A.N. Kabanov, Forest Journal **6**, 104-117 (2019). https://doi.org/10.17238/issn0536-1036.2019.6.104
22. M.A. Kirienko, I.A. Goncharova, Siberian Forest Journal **1**, 65-70 (2018). https://doi. org/10.15372/SJFS20180107
23. I. Kuneš et al., iForest. **10(1)**, 121-127 (2016). https://doi.org/10.3832/ifor1578-009
24. A.R. Muhametshina, et al., Forest Bulletin **24(3)**, 81-86 (2020). https://doi.org/10.18698/2542-1468-2020-3-81-86
25. R.A. Shchukin, et al., BIO Web of Conferences **23** (2020). https://doi. org/10.1051/bioconf/20202301009
26. V.V. Ostroshenko, V.Yu. Ostroshenko, L.Yu. Ostroshenko, E.N. Drigin, Pat. 166485. RF, MPK A01C 7/02. Manual seeder / 2016117084/13; decl. 28.04.2016; publ. 27.04.2016. Bull. № 33. p. 2