Forest plantations of the foothills of the North Caucasus and their environmental and economic assessment

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Abstract. Foothill forest plantations of the Karachay-Cherkessia Republic are considered in this paper. The plantations are created by sowing and planting, strip or group tree espacement, both clear and mixed in composition. Thirteen permanent test plots with a total area of 4 hectares were laid. Six of them were laid in the Cherkessk-Elista-Volgograd State Forest Protection Zone (the Stalin's Nature Transformation Plan of 1948). Complete enumeration of trees was carried out on each trial plot, defining their preservation, condition and quality. Models (from the trees of medium diameter and height) were selected. The graphs of growth progress in height and diameter were constructed. The calculation of barrel and stock volume was based on special tables. Environmental and economic assessment of the plantations (Kuban forestry, the Karachay-Cherkessia Republic) was carried out. The assessment was based on the methodology by V Tarankov. The calculation of carbon reserves was carried out by the calculation and measurement method using special tables. The current growth of plant phytomass was calculated through the intensity of carbon sequestration. Assessment of carbon dioxide absorption and oxygen evolution was carried out by the calculation method. The research is based on the method of comparison and analysis using variation statistics, which significantly improved the reliability of the data. For the first time, the experience of creating forest plantations in the foothills of the Karachay-Cherkessia Republic is summarized. The research makes a basis for planning and reconstruction of artificial stands in the foothills of the North Caucasus (eastern part).

1. Introduction

Forests of the North Caucasus perform important water conservation and soil protection functions and have recreational significance. They are the main sources of wood, both oak and other hardwood species. In recent years, the forests of the North Caucasus have been heavily used. In this regard, important issues of their recovery and productivity arise.

The complexity of the problem is caused by the fact that the forests are located on the mountain slopes. They are distinguished by a variety of forest conditions and characterized by low productivity. A lot of problems of oak forest restoration and cultivation are poorly studied.

It should be noted that low productivity of the North Caucasus forests (their part) is explained by soil and climatic conditions and anthropogenic impact in the distant past. In other region it happens due to vegetative origin. Most of the operating stock of forest stands has been logged more than once.

Most of the studies in the field of artificial reforestation and afforestation were carried out in the western part of the northern macro slope of the North Caucasus (Krasnodar Territory, Adygea). The research in the eastern part of the North Caucasus republics is almost absent. The studies cited in this
work partially overlap with those by the scientists from many countries, dealing with environmental issues and ecological and economic assessment of plantations. At the same time, considering the environmental and economic assessment as a calculation of costs and obtaining benefits, profitability of plantings, the problem is relevant at present. So, according to the research results, an economic assessment of the environmental impact will increase the economic profitability of forest stands by 20-90% [1]. Environmental and economic assessment of plantations will significantly change the economic profitability of stands in forestry, and clearly shows us the economic importance of intangible environmental effects [2].

The principal aim of this work is to restore the indigenous types of forests and the formation of protective phytocenoses by creating artificial stands of higher productivity, stability, and quality [3-5]. The results of the study showed a positive trend. They can be used not only in the Karachay-Cherkessia Republic, but also in the adjacent eastern territories under similar climatic conditions. The used approaches and assessment methods can be applied by forestry workers, both in Russia and abroad.

2. Material and methods
Karachay-Cherkessia Republic is located in the zone of mountain steppes and deciduous forests. In the steppe conditions, forest stands are located on black soils. They perform mainly protective functions. In the area of our research, forestless areas are represented by wastelands, glades and forest meadows. The research was conducted on the territory of the Republican State Institution "Kuban Forestry". It is the eastern part of the Karachay-Cherkessia Republic (KCR).

The studies were carried out on the territory of Kuban forestry (Prigorodnoye, Dzhegutinskoe and Kholodno-Rodnikovskoe local forest districts) – the eastern part of the Karachay-Cherkessia Republic. The forests of Kuban forestry are a combination of forest arrays, located among agricultural lands. Plantations are pure and mixed in composition; they grow under the same growing conditions (D2) – “fresh oak wood”, age from 48 to 63 years [6,7]. Soils are gray forest and typical mycelian-carbonate thick black soils.

Soil and climatic conditions enable English oak to be the main forest-forming species with an admixture of European ash, Norway maple, white maple, and locust. It contributes to the formation of highly productive mixed plantation [8,9].

Before laying the trial plots, a reconnaissance survey of the forest crops planned for the study was carried out in order to determine their general condition.

Trial plots were laid, the size of which was set depending on the age. The number of trees in the trial plot was not less than 200 pieces.

The long sides of the trial plot were located in the direction of the rows. The borders were drawn in the middle of the row spacing. The short sides were limited using sighting lines without cutting trees. Chalk marks were made on the trees bordering the trial plot. Right angles were marked with a measuring fork. At the corners of the test area, temporary pegs were installed. The distance from the edge of the forest or road to the border of the trial plot was not less than the height of the stand.

The studies were carried out in 57-year old oak and ash trees, Kuban forestry, Prigorodny district forestry. On permanent sample plots (quarter No. 7 (stratum 18), quarter No. 8 (stratum 4)), crops were created on cutting areas by planting, with a distribution of 3×0.7 and 2.5×1 m. The soils are gray forest.

The taxation characteristics of oak and ash trees on the fresh cutting area are presented in Table 1. The next objects of the study were European ash plantations, pure in composition, and with an admixture of Oriental beech and Norway maple. Plantations were created on the lands that were out of agricultural use. Gray forest soils are located under agricultural land.

Two permanent sample plots were laid to assess the plantations. The size of test plots was 0.5 ha, age – 48 and 59 years. They were created by planting, distribution – 2×1 m, growing conditions – D2. The taxation characteristics of ash cultures are presented in Table 2.
White maple (sycamore) is a common tree species often found in artificial stands in the North Caucasus and the Crimea [3,10-12]. On the territory of Kuban forestry in quarter No. 16 (stratum No. 32), white maple cultures have the following composition: 8Wm2Ea. The plantations were created by planting with a distribution of 2×1 m. The type of growing conditions is fresh oak wood (D2). Soils are gray forest. Cultures are created on the territory of pasture. Safety is 32%. The undergrowth is represented by single ash trees with a height of up to 0.5 m. The underbrush is English field maple and elder tree (1 m high). Data on the characteristics of white maple cultures are presented in Table 3.

Table 1. Characteristics of oak and ash trees on the cutting area.

| No | No. quarter | No. stratum | Area, ha | Composition | Age, years | Hav±m, m | Dav±m, cm | Growth class | Forest site type |
|----|-------------|-------------|---------|-------------|------------|----------|-----------|-------------|-----------------|
| 1  | 8           | 4           | 33      | 4Eo4Ea1A1Lo+Ew | 57         | 19±0.61  | 22±0.82   | III         | D2              |
| 2  | 7           | 18          | 18      | 4Eo4Ea2Lo+Ew+Pr | 57         | 18±0.66  | 20±0.75   | III         |                 |

Note* Eo – English oak; Ea – European ash; A – apricot; Lo – locust; Ew – European walnut, Pr – wild pear tree.

Table 2. Characteristics of European ash plantations.

| No | No. quarter | No. stratum | Area, ha | Composition | Age, years | Hav±m, m | Dav±m, cm | Growth class | Forest site type |
|----|-------------|-------------|---------|-------------|------------|----------|-----------|-------------|-----------------|
| 3  | 9           | 4           | 5.3     | 8Ea2Ga     | 62         | 18±0.58  | 20±0.62   | I           |                 |
| 4  | 9           | 18          | 1.3     | 10 Ea      | 48         | 18±0.43  | 18±0.55   | I           |                 |
| 5  | 13          | 1           | 13      | 10Ea+Lo+A  | 61         | 18±0.61  | 22±0.83   | I           |                 |
| 6  | 18          | 5           | 2.7     | 10 Ea+ Bc, Nm | 59         | 20±0.80  | 20±0.67   | I           |                 |

Note*; Ea – European ash; Ga – Green ash; Lo – locust; A – apricot; Bc – beech, Nm – Norway maple.

As it has been mentioned earlier, another studied object was the State Protective Forest Belt, located on the territory of Kuban Forestry, KCR. The soils are mineral-carbonate black soils. The type of growing conditions is fresh oak wood (D2). Six permanent test plots were laid in different areas of the State Protective Forest Belt Cherkessk-Elista-Volgograd (quarter No. 1 (stratum 1, 25), quarter No. 3 (stratum 1), and quarter No. 8 (stratum 1, 67, 82). The composition of plantations is presented in Table 4.

Table 3. Characteristics of white maple plantations.

| No | No. quarter | No. stratum | Area, ha | Composition | Age, years | Hav±m, m | Dav±m, cm | Growth class | Forest site type |
|----|-------------|-------------|---------|-------------|------------|----------|-----------|-------------|-----------------|
| 5  | 16          | 32          | 1.8     | 8Wm2Ea 8Wm  | 63         | 15±0.31  | 16±0.48   | II          | D2              |

Note* Wm – white maple; Ea – European ash.

Table 4. Composition of plantations in State Protective Forest Belt Cherkessk-Elista-Volgograd.

| No | No. quarter | No. stratum | 1985 Tree-stand composition | 1997 Tree-stand composition | 2015 Tree-stand composition |
|----|-------------|-------------|------------------------------|----------------------------|-----------------------------|
| 1  | 1           | 1           | 9Se1Lo                       | 9Se1Lo+Lo                 | 9Se1Lo+Lo                  |
| 2  | 2           | 25          | 3Ew5Ea1Se1Lo                | 3Ew5Ea1Eo1Se+Lo+A        | 8Ea2Se+Lo                  |
| 3  | 3           | 1           | 5Se2Wm2Ew1Hl                | 5Se3Wm2Ew1Hl             | 5Wm1Se 2Ew2Hl             |
| 4  | 1           | 1           | 6Ew2Eo2Bp                   | 6Ew2Eo2Bp+Se            | 7Ew2Eo1Bp                  |
| 5  | 8           | 67          | 6Eo2Ea1Lo1Sp                | 6Eo2Ea2Lo+Co            | 6Eo2Ea2Lo                  |
| 6  | 8           | 82          | 8Ew1Ea1Lo+A                 | 7Ew2Ea1Lo               | 7Ew2Ea1Lo                  |

Note* Se – Siberian elm; Lo – locust; Ew – European walnut; Hl – honey locust; Eo – English oak; Bp – Black poplar, Sp – Scots pine, Wm – white maple, Ea – European ash; A – apricot.
3. Results and discussion

English oak and European ash can be seen very often in the zone of mountain steppes and deciduous forests on the gray forest soils [13]. This is explained by the fact that preference is given to oak as the main species in this zone. Growth characteristics of English oak mixed with European ash are given in Table 5.

Table 5. Growth and productivity indicators of 57-year-old oak and ash plantations.

| No. quarter | No. stratum | Species      | The number of trees per 1 ha, pieces | Average height, m | Average diameter, cm | Wood stock per permanent sample plot, m³ | Wood stock per 1 ha, m³ |
|-------------|-------------|--------------|--------------------------------------|-------------------|----------------------|------------------------------------------|------------------------|
| 7           | 18          | English oak  | 76                                   | 18                | 20                   | 36                                       | 148                    |
|             |             | European ash | 112                                  | 17                | 18                   | 17                                       | 68                     |
| 8           | 4           | English oak  | 120                                  | 19                | 22                   | 38                                       | 152                    |
|             |             | European ash | 116                                  | 17                | 20                   | 20                                       | 80                     |

From the data presented in Table 5, we see that at the age of 57 years, oak and ash trees in quarter No. 8 (stratum 4) are the most productive ones. This is achieved due to a larger number of English oak trees in the plantations. The participation of European ash and other related species in the composition has a positive effect on soil conditions, preventing the appearance of grass and unwanted woody vegetation. Figures 1-2 show the growth curves of oak and ash trees in height and diameter.

![Figure 1](image1.png)

*Quarter No. 7 (stratum 18)*

*Figure 1.* The growth course of European ash in height, m and the growth course of English oak in height, m.

![Figure 2](image2.png)

*Quarter No. 8 (stratum 4)*

*Figure 2.* The growth course of European ash in diameter, cm and the growth course of English oak in diameter, cm.

Based on these figures, it can be seen that European ash lags behind English oak throughout the entire growth period in height and diameter. This is explained not only by different biological properties, but also by different morphological and anatomical features. After examining the cultures of ash, listed in Table 6, it has been found that European ash forms highly productive, stable stands on gray forest soils under conditions of fresh oak wood (D2). At the same time, one of the plantation
features is a complete absence of ground cover – “dead cover”. This is due to the fact that the crowns of beech, maple are in the same tier with ash. This contributes to a good clearing of the branches and formation of full-boled trunks. Data on the growth and productivity characteristics of European ash cultures are presented in Table 6.

| No. quarter | No. stratum | Area of permanent sample plot, ha | Species       | The number of trees per 1 ha, pieces | Average height, m | Average diameter, cm | Wood stock per permanent sample plot, m³ | Wood stock per 1 ha, m³ |
|-------------|-------------|----------------------------------|---------------|-------------------------------------|-------------------|----------------------|------------------------------------------|------------------------|
| 9           | 4           | 0.5                              | European ash  | 880                                 | 18                | 20                   | 113                                       | 226                    |
| 9           | 18          | 0.5                              | European ash  | 2 486                                | 18                | 18                   | 78                                        | 157                    |
| 13          | 1           | 0.5                              | European ash  | 894                                 | 18                | 22                   | 85                                        | 170                    |
| 18          | 5           | 0.5                              | European ash  | 1 156                                | 20                | 20                   | 149                                       | 299                    |

Thus, it can be argued that the created cultures of ash trees form highly productive plantations, pure and mixed in composition, in the conditions of the foothills of KCR. The stock at the age of 50-60 years is up to 300 m³/ha.

In quarter No. 18, pure and mixed Norway maple cultures are created at former hayfields. Norway maple at a young age (the first decade of its development) is fast-growing tree species. The height growth is 1–1.5 m (up to 40–50 years) on the best soils. Then it slows down, and the maple gradually passes into the second tier.

Table 3 shows that European ash exceeds white maple in height and diameter. Plantings are characterized by high density. The density is 0.9. High density persists in the middle age. Light does not penetrate under the canopy, which excludes the possibility of soil sodding. White maple cultures show a productive stock of stem wood at the age of 63 years (128 m³/ha). Ash has a positive effect on soil conditions, thereby preventing the occurrence of undesirable vegetation.

Figure 3 presents the growth course of white maple cultures in height and diameter. Height growth of white maple and ash is about the same up to 20 years. There is a slight advantage of European ash starting from 25. Ash has a clear advantage over white maple in diameter from the age of 5.

![Figure 3](image)

**Figure 3.** The growth course of white maple plantations in height and diameter: (a) the growth course of white maple in height, m and the growth course of European ash in height, m; (b) the growth course of white maple in diameter, cm and the growth course of European ash in diameter, cm.
Based on the obtained data, white maple can be recommended as economically valuable tree species. Physical and mechanical properties of maple wood are close to oak ones. Its quality is higher than that of the coniferous wood.

Siberian elm is the main species in the composition on sample plot 1 in the State Protective Forest Belt Cherkessk-Elista-Volgograd. European ash has replaced locust (*Robinia pseudoacacia* L.). European ash has replaced walnut from the main species on the second test plot. In addition to this, English oak fell out of the composition. White maple has replaced Siberian elm in the test plot 3, taking the place of the main species.

European walnut (on the 4th test plot) remained the main species in the composition with the addition of Siberian elm and Norway maple, but later Siberian elm dropped out of the composition. European ash and locust remained accompanying species of English oak on the fifth test area. Scots pine fell out of the composition.

European ash and locust (on the 6th test plot) are the accompanying species for European walnut. There are no changes in the composition (Table 7).

**Table 7. Characteristics of plantations of the State Protective Forest Belt.**

| No. quarter | No. stratum | Area, ha | Species | Age, years | Hav±m, m | Dav±m, cm | Density | Growth class | Wood stock per 1 ha, m³ |
|-------------|-------------|----------|---------|------------|----------|------------|---------|--------------|----------------------|
| 1           | 1           | 1.8      | 9Se1Ea+Lo | 52         | 10±0.101 | 16±0.079  | 0.7     | IV           | 58                   |
|             | 2           | 25       | 8Ea2Se+Lo | 62         | 15±0.063 | 22±0.071  | 0.7     | II           | 144                  |
|             | 3           | 4.3      | 5Wm1Se 2Ew2Hl | 62         | 16±0.032 | 20±0.090  | 0.8     | II           | 236                  |
|             | 1           | 4.3      | 7Ew2Eo1Bp | 62         | 16±0.064 | 22±0.102  | 0.6     | II           | 100                  |
|             | 6           | 2.3      | 6Eo2Ea2Lo | 62         | 16±0.055 | 24±0.066  | 0.6     | II           | 100                  |
|             | 8           | 3.8      | 7Ew2Ea1 | 62         | 16±0.062 | 22±0.089  | 0.7     | II           | 214                  |

There is a clear advantage of Siberian elm over European ash in average height – by 20%, in diameter – by 12% (quarter No. 1, stratum 1). The total stock is 58 m³, 90% of which is formed by Siberian elm. Density is 0.7. Growth class is IV. Soil salinity gave the main influence on the species composition, growth and productivity. In quarter No. 1, stratum 25, on the contrary, European ash occupies a leading position in average height by 20%, in diameter – 27%. In this case, the total stock is 144 m³, 80% of which is formed by European ash. Density is 0.7. Growth class is II. White maple (quarter No. 3, stratum 1), both in height and in diameter, is ahead of walnut, honey-locust and Siberian elm by 12 and 10%. The total stock is 236 m³, 50% of which is white maple. Density is 0.8. Growth class is II. English oak and black poplar (quarter No. 8, stratum 1) both in height and diameter are inferior to European walnuts by 12 and 10%. The total stock is 100 m³, 70% of which is walnut. Density is 0.6. Growth class is II. In quarter No. 8, stratum 67, the advantage of English oak over
European ash and locust is seen: in average height – by 12% and in diameter – by 17%. The total stock is 100 m³, 60% of which is English oak. Density is 0.6. Growth class is II. European ash (Quarter No. 8, stratum 82) is ahead of walnut and locust in height and in diameter by 12 and 9%. The total stock is 306 m³, 20% of which is ash trees. Density is 0.7. Growth class is II.

We further examined the age changes in the plantations in the State Protective Forest Belt (SPFB). The data are presented in Table 8.

### Table 8. Dynamics of stock changes in the State Protective Forest Belt, m³/ha.

| No. permanent sample plot | No. quarter | No. stratum | Tree-stand composition          | 1985 | 1997 | 2015 |
|--------------------------|-------------|-------------|---------------------------------|------|------|------|
| 1                        | 1           | 9           | 9Se1Lo                          | 50   | 50   | 58   |
|                          | Age, years  | 25          | 3Ew5Ea1Se1Lo                    | 32   | 44   | 62   |
|                          | Stock, m³/ha| 70          | 5Ew2Ea2Eo1Se+Nm                 | 32   | 44   | 62   |
|                          |             | 90          | 6Ew2Eo2Bp                       | 90   | 100  | 100  |
|                          | Age, years  | 82          | 8Ew1Ea1Lo+A                     | 32   | 44   | 62   |
|                          | Stock, m³/ha|             | 100                             | 100  | 100  | 100  |

With advancing age, the stock in stands of the State Protective Forest Belt increases. So, the minimum stock values are observed on the sample plots No. 1, No. 4, No. 5 (58, 100, 100 m³/ha), and the maximum one is on test plot No. 6, amounting to 306 m³/ha.

Conducting an environment and economic assessment of artificial plantations, it is necessary to remember that the growth energy of the stands is objectively reflected by the size of their average increase in stock. So, the maximum value of growth is observed in the stands of European ash trees located in Dzhegutinsky forest district (by the age of 59 years, it is 5.1 m³/ha per year), and the minimum value of growth is observed in the cultures of Siberian elm in Kholodno-Rodnikovsky forest district (the current stock increment is 1.1 m³/ha per year at the age of 52).

With age, there is a decrease in stock growth. Destruction of forest stands occurs, and the magnitude of loss of the growing forests begins to exceed the growth [14].

In Prigorodnoe and Dzhegutinsky forest districts, the maximum values of carbon stock in the phytomass of tree stands by species are shown by ash (155.1 t/ha and 146.5 t/ha), English oak (131.8 t/ha and 128.3 t/ha). Locust and cherry plum show the minimum stocks (9.4 t/ha and 8.5 t/ha). Kholodno-Rodnikovsky forest district has the same situation in Kholodno-Rodnikovsky forest district. The maximum carbon stock in ash wood is 184.4 t/ha, the minimum value is shown by the crops with Siberian elm. In quarter No. 1, stratum 1, 9Se1Ea cultures grow on saline soils. Carbon stock is small in the phytomass (43.7 t/ha – Siberian elm tree, 4.3 t/ha – European ash tree).

Thus, Siberian elm plantations show the smallest accumulation of carbon, which also affects the composition, growth and productivity of plantations. Talking about the oxygen supply in the phytomass of the forest stands of Prigorodnoye and Dzhegutinsky forest districts, European ash gives 690.8 t/ha and 416 t/ha, English oak – 353.2 t/ha and 344 t/ha. Locust and cherry plum show the minimum accumulation of oxygen – 25.1 t/ha and 22.7 t/ha. Kholodno-Rodnikovsky forest district has...
the maximum oxygen stock in the stands of European ash. The oxygen content in the phytomass is 494.3 t/ha. The minimum value falls on cultures with Siberian elm (54 t/ha) and European ash (11.5 t/ha).

Carbon sequestration is accompanied by the absorption of carbon dioxide and release of oxygen. The maximum amount of carbon dioxide in all forest areas is absorbed by the phytomass consisted of European ash and English oak. At the age of 59, European ash absorbs 931.9 t/ha of carbon dioxide and release 690.8 t/ha of oxygen. English oak cultures show the maximum amount of absorbed carbon dioxide (947.6 t/ha) and released oxygen (353.2 t/ha) by the age of 57. The maximum amount of absorbed carbon dioxide (158 t/ha) and released oxygen (117.3 t/h) have been seen in Siberian elm plantations of Kholodno-Rodnikovsky forest district. There are quite high rates of absorbed carbon dioxide and oxygen emission up to 63 years.

The resulting studies enable to estimate the annual absorption of carbon dioxide and release of oxygen in the plantations under study. In cultures where European ash acts as the main and accompanying species, average annual phytomass growth ranges from 0.1 t/ha to 3.8 t/ha, depending on the species share in the composition. In English oak plantations, the average annual phytomass growth ranges from 0.2 t/ha to 2 t/ha. White maple, walnut, Siberian elm has an average annual phytomass growth from 0.4 t/ha to 1.6 t/ha. Knowing the annual flow of CO₂ to the black soil (9.4 t/ha) and the value of C accumulated during the phytomass increase, we calculate the carbon stock for forest ecosystems.

Carbon dioxide absorption and oxygen emission are directly dependent on the value of annual phytomass increase. In economic terms, the assessment of plantations began with the calculation of stocks of non-timber forest products. The calculation of stocks of non-timber forest products was made as follows: the characteristics of strata were extracted from taxation descriptions to determine the amount of green wood per 1 m³ of stem wood. Multiplying the stock of stem wood by stratum by the corresponding standard, we get a stock of resources.

In Kuban forestry, the biological productivity of non-timber forest products was: green wood – 833.98 c/m³, needles/foliage – 232.92 c, tanning bark – 11400 kg (Table 9).

Table 9. Summary sheet of forest resource assessment in Kuban forestry.

| Types of forest uses                      | Cost, thousand rubles | %       |
|------------------------------------------|-----------------------|---------|
| **Timber**                               |                       |         |
| Average, m³                              | 1014.78004            | 0.08    |
| Small, m³                                | 26.20973              | 0.002   |
| Overall value                            | 1040.990              | 0.1     |
| **Secondary timber**                     |                       |         |
| Green wood                               | 17.848                | 0.001   |
| Tanning bark                             | 18784.920             | 1.51    |
| Overall value                            | 18802.768             | 1.5     |
| **Forest use for environmental purposes**|                       |         |
| O₂ release, t                            | 1208 620              | 97.3    |
| BAS release, t                           | 2.166                 | 0.00    |
| Dust retention, kg                       | 31.760                | 0.002   |
| Overall value                            | 1208653.926           | 97.3    |
| Economic value of land                   | 13228.8               | 1.1     |
| Total for types of forest uses           | 1241726.484           | 100     |

Next, we calculate the stock of phytomass and the surface area of leaves using the data of calculations made in assessing the carbon deposition and oxygen-producing functions of forest plantations. The stock of forestry phytomass for each species was as follows: English oak – 290.5 tons, European ash – 1009.5 t, locust – 100.1 t, European walnut – 117 t, green ash – 33.9 t, white maple – 153.1 t, Siberian elm – 56.7 t, honey-locust – 37.5 t, black poplar – 5 t.
The average fraction data, in percent, were used to determine the mass of the leaves. According to some authors, the foliage weight is 10–15% of the total stock of phytomass. Leaf area was defined as the multiplication of the standard by foliage weight.

The stock of the most part of tree species does not exceed 150 m² in the territory of Kuban forestry. Oak and ash trees (quarter No. 8, stratum 4) with a stock of more than 150 m² make an exception. Thus, it can be concluded that a large area of the forestry is occupied by plantations in which timber is the main type of forest resources.

4. Conclusion

Based on the experience and results of the research, it can be said with confidence that proper selection of tree and shrub species, their mixing and distribution, cultivation technology (soil preparation, planting and sowing, timely care) are necessary for successful cultivation of sustainable, durable protective forest plantations.

It is necessary to introduce shrub vegetation in plantations. This vegetation has a positive effect on the stand conditions during the soil deterioration.

Mixed plantations of State Protective Forest Belt Cherkessk–Elista–Volgograd are characterized by the best performance. They are more stable and grow faster. Crown thickening takes place earlier; they have a better renewability and ameliorative effect.

The species composition, location, and age have a significant impact on the productivity of plantations. The effectiveness of carbon deposition and oxygen-producing functions of forest stands is directly dependent on their phytomass. Plantations absorb carbon dioxide, deposit carbon and release oxygen intensively between the ages of 48 and 63. The exception is the Siberian elm plantations because of their growth on saline soils. The intensity of carbon-depositing and oxygen-producing functions is significantly reduced, which affects the composition, growth and productivity of plantations.

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