Research paper

Ukrainian plain oak forests and their natural regeneration

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Abstract. Changes in the areas and stock volumes of oak stands were analyzed within the six administrative regions in the plain area of Ukraine, based on forest management data (subcompartment database) as of 2001 and 2016. The studied regions geographically related to the Left-bank Forest-Steppe zone of Ukraine (Kyiv, Poltava, Sumy, Kharkiv, Cherkasy and Chernihiv Regions). The analyzed area was over 284,000 hectares. The paper outlines the present state of the oak stands, concerning their origin (vegetative, natural seed and planted seed stands). Forestry-taxation indices of the stands were determined by grouping the plots according to age and further clustering in four age groups. The natural regeneration under a canopy in oak stands was accounted and estimated using circular 10 m² (R = 178 cm) accounting plots. The oak forests were found to be dominated by stands of vegetative (cop-pice) origin (57%). Planted seed-origin oak stands covered 101,000 ha or 36% of the total area (284,000 ha). Stands of natural seed origin amounted to 7%. From 2001 to 2016, the total area of oak forests in the study region decreased by nearly 7,000 hectares. The analysis of literature sources allowed identifying numerous factors, which have the greatest influence on the emergence, liveability, and growth of natural regeneration of pedunculated oak. Only 20% of the investigated oak stands were found to have a sufficient amount of oak regeneration. For the implementation of sustainable forest management, activities should be aimed at optimizing the age structure of oak forests and growing natural forests from seeds.

Key words: common oak, origin, age class, young seedlings, small-sized regeneration, seedling abundance, close-to-nature forestry, sustainable forest management.

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Introduction

Ukraine belongs to the countries with a relatively low average forest cover, since only 15.9% (9.6 million hectares) of the territory is forested. Ukraine ranks only ninth in Europe by forest area (Directory, 2016). Scots pine (Pinus sylvestris L.) (35%) and pedunculate oak (Quercus robur L.) (28%) grow in total on 63% of forest area and are the main forest-forming species in Ukraine (State, 2016).

Oak is one of the most valuable species performing important ecological and pro-
tective functions (Tkach & Golovach, 2009). Its timber is superior to all tree species that grow in Ukraine in strength, colour, texture, and capability of taking a polish. Oak is an indispensable species in protective forest planting in the steppe. In particular, it is used for field shelterbelts and conservation afforestation (Vehkhov, 1954).

The oak forests in Ukraine, as elsewhere in Europe, have undergone continuous cutting followed by agricultural land-use change for four centuries (16th–19th) (Lindbladh & Foster, 2010). In many oak stands, the natural genesis was disturbed, and their age and species compositions changed (Aldrich et al., 2003).

In the second half of the 20th century, there was a tendency to gradually expand the forests with the predominance of the pedunculate oak in Ukraine. For example, over the last 50 years, the area of oak forests has increased by 400,000 hectares – from 1.3 to 1.7 million hectares (Kopiy et al., 2017).

Regeneration of oak forests predominantly means artificial planting of forest stands. Natural regeneration, in particular by seeds, has received little attention. In the first half of the 20th century, there was no problem of regenerating oak forests naturally. The analysis of age-class composition shows significant areas of natural oak forests over 70 years old. In the 1990s, the annual reforestation in Ukraine amounted to an average of 14,000 hectares, in particular, the area of planted forest stands was 12,000 hectares, or 86% (Kopiy et al., 2017). However, now the formation of a new generation of valuable oak forests of natural origin raises concerns. Natural regeneration processes are insufficient and, as a consequence, the area of natural oak forests decreases. The almost entire absence of up to 40-year-old natural oak stands in the forest fund confirms this fact. Successful natural regeneration requires optimal conditions for the emergence and growth of young seedlings, as well as the elimination of the adverse impact of environmental externalities (Hasanov et al., 2017). The issue of natural seed regeneration of oak forests is still urgent for the Ukrainian forestry sector.

Increased anthropogenic impact and climate change (Iverson et al., 2018) have adversely affected natural oak regeneration. The absence or insufficient numbers of new oak seedlings contribute to oak replacement by secondary and associate tree species such as Acer platanoides L., Acer campestre L., Ulmus glabra Huds., Corylus avellana L., Populus tremula L., etc. As a result, valuable oak forests become overgrown or turn into less valuable forests of other species. This reduces the area of oak forests and is a matter of concern to foresters and researchers.

The aim of the research was to analyze the current area of oak stands, identify the specifics of occurrence, retention, and growth of natural regeneration of economically valuable species under the canopy of oak stands as well as to develop methods of nature-friendly forestry as a way to sustainable forest management in the Ukrainian plain oak forests.

**Materials and Methods**

The object of the study was the state oak forests in the Left-bank Forest-Steppe zone of Ukraine. The total area of the studied forests was over 610,000 hectares, including more than 284,000 hectares of oak forests growing in Kyiv, Poltava, Sumy, Kharkiv, Cherkasy and Chernihiv administrative regions (Figure 1).

The study covered natural, of seed and vegetative origin, and planted pure and mixed oak stands within the range of Quercus robur. Forests of 30 state forest enterprises (SFE) were studied within six abovementioned administrative regions.

By geographical latitude, Zmiyivske SFE in Kharkiv Region (49°40’51” north latitude) is the southernmost and the closest to the Steppe zone, and Krokevetske SFE in
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The Sumy Region (51°33'16" north latitude) is the northernmost. By geographical longitude, Boryspilske SFE in the Kyiv Region (30°57'25" east longitude) limits the study area in the west and Vovchanske SFE in Kharkiv Region (36°56'46" east longitude), in the east.

The study area belongs to the fresh fairly fertile forest site type with a temperate climate. The annual precipitation is 520 mm, of which about 70% (370–390 mm) falls during the warm period of the year. The length of the growing season is 195 days. The sum of the average monthly above-zero temperatures reaches 98.3 °C (Ostapenko & Tkach, 2002).

The study was based on the analysis of forest inventory materials (databases of the forest distribution in Ukraine) containing certain forestry-taxation indices of stands as well as data from literature sources for describing the distribution of oak forests.

Forestry-taxation indices of natural modal stands were determined by group- ing the sites by age. The age of the studied oak forests ranged from 1 to over 220 years. They were conventionally grouped into “age classes”, each class encompassing ten years. The “age class” is assumed at ten years as such stands have the same economic value and regeneration ability. To compare the age structure of the stands in terms of their origin, they were conditionally grouped into four age groups as follows: the first group included the stands of up to 40 years old, the second group contained the stands aged from 41 to 80 years, the third group covered the stands aged from 81 to 120 years and the fourth group, stands aged 121 years and over.

Forest typological survey of oak forests was conducted based on Ukrainian forest ecological typology. According to this, a forest type is considered as a set of forested areas similar in climatic, soil, and hydrological conditions. Forest types are characterized by the climate patterns in certain edaphic conditions. The key indicators to

Figure 1. Location of the study site.
single out a specific forest type were the dendrological composition of indigenous stands and the lists of indicator plants (Pogrebnyak, 1955; Vorobyov, 1967; Ostapenko & Tkach, 2002). The names and indices of forest types are given according to the classification list of forest types for the Forest-Steppe zone in the plains of Ukraine (Ostapenko, 1997).

Natural regeneration was counted and assessed in accounting plots. At least 100 circular accounting plots of 10 m$^2$ each ($R = 178$ cm) were established under the canopy of each of the 15 studied oak stands, which made up at least 5% of the stand area. Healthy natural regeneration with no visible signs of damage was divided by tree species, age groups, and height groups. The oak species were assigned to the following four groups, according to their age: young seedlings (plants of the first year of life), 2–3-year-old regeneration, 4–8-year-old regeneration, and 9–15-year-old regeneration. For that, trunks in 10 individuals were cut near the root collar, and the numbers of annual rings were counted.

Depending on the height of the young oaks from the root collar to the apex, a small-sized regeneration (up to 0.5 m high), a medium-sized regeneration (0.5–1.5 m), and a large-sized regeneration (over 1.5 m) were distinguished.

The success of natural regeneration was evaluated by the scale developed in the Ukrainian Research Institute of Forestry and Forest Melioration (Pasternak, 1990). The assessment took into account the quality and number of natural reproduction as well as its abundance under the canopy of oak stands. The abundance of natural reproduction was estimated as the ratio of the number of plots with the reproduction to the total number of accounting plots in oak stands, expressed as a percentage. There were the following three categories: (i) natural regeneration evenly spaced over the area (abundance of more than 65%); (ii) natural regeneration unevenly spaced over the area (abundance of 40–65%); (iii) natural regeneration spaced on the area in groups, of at least ten small-sized healthy individuals or five medium-sized and large-sized healthy individuals in a group.

If the existing natural regeneration belonged to several groups by age and height, its quantity was converted to the 4–8-year-old large-sized regeneration, using the corresponding conversion factors. For that, we used a factor of 0.5 for small-sized individuals and 0.8 for medium-sized ones. For the age conversion, a factor of 0.7 was used for 2–3-year-old regeneration and 1.6 for 9–15-year-old regeneration. After the calculations, we obtained the number of natural regeneration in terms of 4–8-year-old large-sized individuals. The regeneration success rate was considered to be “good”, if the healthy natural regeneration at the age of 4–8 years amounted to more than 6,000 stems ha$^{-1}$ and its abundance was above 65%. The rate was “sufficient” for 3,000–6,000 stems ha$^{-1}$ and the abundance of 40–65%. The regeneration success rate was assessed as “insufficient” for 1,500–2,900 stems ha$^{-1}$ and the abundance of 20–39% and it was “bad” for the less than 1,400 stems ha$^{-1}$ and the abundance of below 20%.

Results

The analysis of the oak forests within the Left-bank Forest-Steppe zone according to forest inventory materials (as of 2016) showed that the area of oak stands was 284,000 ha. The total number of plots, which were analyzed using forest survey data, was 69,733. The area with pedunculate oak prevailing in the composition (at least 50%) amounted to 232,000 ha, representing almost 82% of the total area of oak stands in the study area. The oak forests were dominated by natural stands of vegetative origin, with an area of 57%; the proportion of planted stands with pedunculate oak in composition was 36%. Natural forests of seed origin amounted to
only 7%. The area of natural stands, where oak was predominant, reached more than 154,000 ha, and the area of planted forests with the predominance of oak was almost 78,000 ha.

There was a decrease in the total area of oak forests as of 2016 in comparison with the data of preliminary forest inventory. Despite the increase by 1,000 ha in the area of planted oak stands to 101,000 ha, the area of natural stands of seed origin decreased by 8,000 ha to 183,000 ha. In total, the area of oak forests decreased by almost 7,000 ha (Table 1). However, the total standing volume has increased by almost 4.5 million ha owing to an increase in the average age of stands, regardless of the origin.

Table 1. Changes in areas and volumes of oak stands within the Left-bank Forest-Steppe zone, Ukraine, in terms of origin, for the period of 2001–2016.

| Origin of oak stands | As of 2001 |       |       | Changes |       |       |
|----------------------|-----------|-------|-------|---------|-------|-------|
|                      | Area (thousand ha) | Volume (million m³) | Area (thousand ha) | Volume (million m³) | Area (thousand ha) | Volume (million m³) |
| Vegetative           | 173       | 43.6  | 163   | 43.5    | -10   | -0.1  |
| Natural seed         | 18        | 4.8   | 20    | 5.7     | +2    | +0.9  |
| Planted seed         | 100       | 17.7  | 101   | 21.5    | +1    | +3.7  |
| Total oak stands     | 291       | 66.1  | 284   | 70.7    | -7    | +4.5  |

The oak forests within the Left-bank Forest-Steppe zone (northeastern part of Ukraine), occupying an area of 284,100 ha, have uneven distribution both within “age classes” and across age groups. The distribution of oak stand areas by age groups is heterogeneous and has certain characteristics depending on the origin (Table 2). The age of maturity for the best natural regeneration of oak stands is 50–80 years and such stands make up more than 45% of the total area.

Table 2. Distribution of oak stands within the Left-bank Forest-Steppe zone by age groups: numerator – thousand ha, denominator – %.

| Origin of oak stands | ≤ 40 | 41–80 | 81–120 | ≥ 121 | Total |
|----------------------|------|-------|--------|-------|-------|
| Vegetative           | 1.1  | 46.6  | 106.3  | 8.9   | 162.9 |
| Natural seed         | 0.2  | 5.5   | 11.8   | 2.4   | 19.9  |
| Planted seed         | 17.5 | 76.4  | 7.3    | 0.1   | 101.3 |
| Total                | 18.8 | 128.4 | 125.3  | 11.4  | 284.1 |
The largest part of the area is occupied by stands of age groups of 41–80 and 81–120 years – 45 and 44% of the total area, respectively. Age groups of ≤ 40 and ≥ 121 years have the smallest percentage – 7% and 4%, respectively. The area of studied oak forests is unevenly distributed among different “age classes” (Figure 2). For example, the area ranges from 2,000 ha for 141–150-year-old forest to 54,000 ha for 81–90-year-old ones. Furthermore, the proportions of forests aged 1–10, 11–20, 21–30, 31–40, 41–120, 121–130, and 131–140 years, account for 2% or less each. The area of forests aged 41–50, 51–60 and 101–110 years is 7–9%. The largest proportion of the area – over 63% – is accounted for 61–100-year-old oak stands. Sustainable management of oak forests in the study area should ensure an even distribution of the stands by “age classes”.

The analysis of forest inventory data on the proportion of pedunculate oak in the stand composition indicated an increasing oak percentage with age of oak stands. The most significant increase in the proportion of oak occurred in stands of vegetative origin, where oak represented 41% at the stand age of 10–40 and increased to 73% at the age of 120. In natural oak stands of seed origin, the change in oak proportion...
was less significant – from 50% to 72%. In planted oak stands of seed origin, oak proportion in the composition increased only up to 80 years and was 69%; it was 56% at the age of 40 (Figure 3). The reason is that foresters can control the composition of the planted stands, using relevant silvicultural practices (intermediate felling) in the initial stage of growth.

In general, pure oak stands covered 57,380 ha or 20% of the total oak forests. Most of them (61%) were stands of vegetative origin. Planted oak stands accounted for 33% of the area and stands of natural seed origin represented 6% of the area. Forested areas with the oak proportion of 30–40% covered 18% of the area of investigated forests.

Discussion

Pedunculate oak grows in all natural zones in Ukraine both in natural and planted stands, except in the southern steppe regions. The best conditions for its success are, however, in the forest-steppe zone. Pedunculate oak is among the main forest-forming species. The proportion of stands with pedunculate oak is 28% in the total area of 9.6 million ha of forests in Ukraine (Tkach & Golovach, 2009; Bala & Khan, 2014). Within the plains of Ukraine (including the Left-bank Forest-Steppe zone), pedunculate oak grows in pure and mixed forests.

The big forest-forming role of pedunculate oak cannot be attributed solely to its biological properties but is also linked to the natural conditions of the area in which it grows. The oak habitat includes the land with various climatic and soil conditions that are favorable for the growth of a significant number of tree species with different and sometimes opposing biological properties (Vekhov, 1954; Carvalho, 2011; Petritan et al., 2012; Vachnadze et al., 2018).

The oak forests of the Left-bank Forest-Steppe zone have great typological diversity, since pedunculate oak grows in 67 forest types in the plains of Ukraine. However, 82% of oak forests are growing within the following four main forest types: fresh fertile maple-lime oak forest, dry fertile maple-lime oak forest, fresh fairly fertile lime-oak-pine forest, and fresh fairly fertile maple-lime oak forest. The smallest areas of stands with oak are concentrated in damp and wet fertile and fairly fertile sites.

The age structure of biocoenoses of forest-forming species reveals a balance of individuals of different chronological ages. Age changes in the stands are irreversible. Therefore, it is necessary to know the age structure and individual specificities of the development of tree species to preserve and regenerate the vegetation. The absolute or chronological age of a plant is a population indicator that contains important information for studying the biocoenoses of forest-forming species. Absolute age is one of the main indicators used in mensuration assessment of stands. Sometimes the phytocoenotic characteristics of forests (structure, sustainability, biodiversity) depend on age structure. Uneven-aged stands are characteristic of both pure and mixed forests not involved in commercial use (Degtyarev, 2017).

Close to nature forestry is the way to achieve sustainable forest management in Ukraine, in particular in the oak forests of the plains. One aspect of sustainable forestry is to ensure uniform distribution of stands by age classes. The distribution of stands by age classes reflects their spatial and temporal distribution. It can be achieved by regulating natural regeneration (Hasanov et al., 2017).

Analysis of age structure and assessment of natural regeneration will allow further prediction and determination of ways for sustainable management of oak forests.

A small proportion, generally less than 1%, of young oak stands under 40 years of age, especially of natural origin, is a consequence of poor reproduction of oak forest.
ests by natural regeneration during the last 40–50 years. After World War II and until today the reproduction of oak forests occurred mainly through the establishment of forest stands. Artificial regeneration of oak stands not only ensured the reproduction of oak forests on large areas that were deforested during the war and postwar period to the needs of the national economy, but also led to the almost complete absence of mature and overmature oak stands of natural origin. Such oak stands are a valuable gene pool for sustainable local populations, as well as key sites for the future formation of a new generation of natural oak forests, in particular of seed origin. Now mature and overmature stands (over 120 years old) make up only about 4% of the total area of oak forests.

The prevailing stands of 61–100 years of age will become mature and overmature in 30–40 years and will thus require reforestation by promoting their natural regeneration or by planting stands.

Oak is one of the most common and yielding forest species in Ukraine. According to the study of Tkach & Golovach (2009), oak forests of natural seed origin are the most resilient and productive.

The success rate of natural oak regeneration depends on many factors, such as the number of oaks in the stand and their age, the relative density of stocking, the acorn yield, sufficient heat, moisture, and light, and the development of shrub and grass layers (Vedmid et al., 2008; Kharchenko & Kharchenko, 2012; Ligot et al., 2013; Dobrovolný, 2014; Levchenko, 2014; Tkach et al., 2014; Annighöfer et al., 2015; Sendonin, 2015; Sevillano et al., 2016).

The natural regeneration of oak forests is significantly influenced by the frequency and intensity of oak fruiting. In the Left-bank Forest-Steppe zone, Ukraine, the fruiting of pedunculate oak has slightly increased in recent years. The data from the 12-year observation period (2003–2014) concerning flowering, fruiting and harvesting of oak acorns by state forestry enterprises within the Left-bank Forest-Steppe zone indicate that on average, a good harvest of acorns was observed once every 3–4 years (Tkach et al., 2015).

Many studies have been devoted to the research of natural oak regeneration (Dobrowolska, 2008; Götmark & Kiffer, 2014; Levchenko, 2014; Annighöfer et al., 2015; Vizoso-Arribé et al., 2015; Jensen & Löf, 2017; Kopiy et al., 2017; Laurent et al., 2017; Bobiec et al., 2018), in particular in the conditions of the Left-bank Forest-Steppe zone of Ukraine (Tkach et al., 1996; Vedmid et al., 2008; Tkach et al., 2014; Rumiantsev, 2015; Tkach et al., 2015; Chygrynets et al., 2016; Rumiantsev & Lyk’yanets, 2016; Tkach et al., 2017; Didenko & Polyakov, 2018; Rumiantsev et al., 2018a, b). At the same time, this area of research remains relevant due to the need to develop ways to increase the area of oak stands, in particular, by promoting their natural regeneration by sowing.

The results of our studies (Tkach et al., 2014; Rumiantsev, 2015; Tkach et al., 2015; Chygrynets et al., 2016; Rumiantsev & Lyk’yanets, 2016; Rumiantsev et al., 2018a, b) show that the highest amount of natural regeneration of pedunculate oak (about 10,000–11,000 stems ha−1) appears after the harvest year under the canopy of open (the relative density of stocking is 0.6–0.7) old (140–190 years of age) oak stands with more than 70% of oak in the composition (Table 3).

By age, natural oak regeneration under the canopy of oak stands belongs predominantly to the categories of young seedlings (plants of the first year of life) and 2–3-year-old regeneration, accounting for 10–100% and 4–85% of the total oak regeneration, respectively (Table 4).
Table 3. The number of natural regeneration of up to 15 years under the canopy of oak stands of different ages, compositions and relative densities of stocking in the dry fertile maple-lime oak forest type in the Left-bank Forest-Steppe zone, Ukraine.

| Sample plot number | Characteristic of oak stands | Age (years) | Relative density of stocking | Total Thousand stems ha\(^{-1}\) | % |
|--------------------|------------------------------|-------------|-------------------------------|---------------------------------|---|
|                    | Stand composition            |             |                               |                                 |   |
| 60–100 year-old stands |                              |             |                               |                                 |   |
| 1                  | Oak 90%–Ash 10%              | 64          | 0.75                          | 9.1                             | 1.9 | 20.9 |
| 2                  | Oak 80%–Ash 20%              | 70          | 0.60                          | 14.8                            | 2.3 | 15.5 |
| 3                  | Oak 80%–Lime 10%–N-Maple 10% | 83          | 0.88                          | 11.1                            | 2.6 | 23.4 |
| 4                  | Oak 60%–N-Maple 20%–Lime 10%–Ash 10% | 84       | 0.61                          | 25.9                            | 1.4 | 5.4  |
| 5                  | Oak 60%–Lime 30%–Ash 10%     | 94          | 0.86                          | 5.9                             | 1.0 | 16.9 |
| 6                  | Oak 60%–Lime 20%–Ash 10%–N-Maple 10% | 100     | 0.66                          | 20.1                            | –   | –    |
| 110–150 year-old stands |                              |             |                               |                                 |   |
| 7                  | Oak 70%–Ash 20%–Lime 10%     | 109         | 0.63                          | 16.0                            | 4.0 | 25.0 |
| 8                  | Oak 60%–Lime 20%–N-Maple 20% | 119         | 0.62                          | 13.1                            | 2.8 | 21.4 |
| 9                  | Oak 60%–Lime 20%–Ash 10%–N-Maple 10% | 134      | 0.86                          | 16.0                            | 2.8 | 17.5 |
| 10                 | Oak 90%–Ash 10%              | 144         | 0.72                          | 17.4                            | 10.3 | 59.2 |
| 160–200 year-old stands |                              |             |                               |                                 |   |
| 11                 | Oak 70%–Ash 20%–N-Maple 10%  | 158         | 0.60                          | 34.7                            | 5.3 | 15.3 |
| 12                 | Oak 70%–Ash 10%–Lime 10%–N-Maple 10% | 158     | 0.62                          | 30.0                            | 11.0 | 36.7 |
| 13                 | Oak 30%–Ash 30%–Lime 20%–N-Maple 20% | 178      | 0.70                          | 15.5                            | 3.0 | 19.4 |
| 14                 | Oak 100%                     | 188         | 0.66                          | 25.0                            | 8.0 | 32.0 |
| 15                 | Oak 100%                     | 193         | 0.69                          | 26.8                            | 10.8 | 40.3 |

Note: Oak = pedunculate oak (Quercus robur L.), Ash = common ash (Fraxinus excelsior L.), N-Maple = Norway maple (Acer platanoides L.), Lime = small-leaved lime (Tilia cordata Mill.).
The number of older regeneration is significantly lower (10–40%) due to severe damage caused by powdery mildew (*Microsphaera alphitoides* Gr. Et Maubl.) and transformation to stump plants. Their particularity is a saber-shaped bend on the stem of the plant with or without signs of the presence of a main stem in previous years. This indicates that growth has stopped due to mechanical damage or poor lighting.

By height, almost all oak regeneration – more than 94% of the total – is in the small-sized category (up to 0.5 m high).

The analysis of the quantity and quality of oak regeneration, its height and age structures indicates that the regeneration success rate is “insufficient” or “poor” (the number of healthy regeneration in terms of 4–8-year-old large-sized individuals does not exceed 3,000 stems ha\(^{-1}\)) by the regeneration success scale (Pasternak, 1990).

There is a close correlation between the number of natural regeneration of the pedunculate oak under the stand canopy (*N*) and its abundance (*Ab*) (*Ab* = 18.364 ln *N* + 35.955; *R*\(^2\) = 0.91). The abundance of wood species in the composition of the reproduction can be used to predict its further proportion in the further composition of the growing stand.

The absence of regeneration indicates a sharp reduction in the area of oak forests in the future. Eliminating the negative factors affecting the natural regeneration and implementing activities to promote reproduction in the oak forests of the region are priority tasks for foresters and scientists.

### Conclusion

Oak stands aged 81–120 years prevail among natural vegetative and seed origin forests within the Left-Bank Forest-Steppe zone in Ukraine (65 and 59%, respectively). Among forests planted by seeds, 41–80-year-old stands are prevalent (76%). A small area is occupied by young stands – up to 7% of the total area of oak forests, regardless of origin. The age structure of the oak stands is unbalanced. The almost complete absence of young oak forests of natural origin (about 1%) is a result of unsatisfactory regeneration of oak forests in the last 40–50 years. Old (mature and overmature) oak stands, which create the most favourable conditions for the emergence and development of natural regeneration, occupy only 4% of the total area of oak forests in the region. Management interventions should aim at optimizing the age structure of oak forests and growing forests of natural seed origin to apply the principles of sustainable forest management.
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