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DYNAMICS OF ARTIFICIAL REGENERATION AND ESTABLISHMENT OF NEW FORESTS IN SERBIA FOR THE PERIOD 2017-2023

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Abstract: In the context of escalating impacts of climate change, improvements in forest conditions, increased carbon sequestration, and environmental improvements, increasing the forest area has become a critical task within forestry. This study aims to analyze the trends in afforestation over the past six years using statistical data.

Analysis of available data reveals significant disparities between afforestation efforts in state-owned versus privately owned forests. In state-owned forests, afforestation with hardwoods is higher by 52.4% compared to conifers, and the largest number of used seedlings are oaks (*Quercus* sp.), followed by poplars (*Populus* sp.), which are followed to a much smaller extent by black locust (*Robinia pseudoacacia* L.), other hardwood and softwood species, and finally beech (*Fagus sylvatica* L.). Among conifers, spruce (*Picea* sp.) and Austrian black pine (*Pinus nigra* J.F. Arnold) dominate, followed by Scots pine (*Pinus sylvestris* L.), fir (*Abies alba* Mill.), Weymouth pine (*Pinus strobus* L.) and Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) with a smaller number of seedlings. In private forests, conifers are afforested 15.6% more, spruce (*Picea* sp.) and Austrian pine (*Pinus nigra* L.) also dominate, while in hardwoods this role is taken over by poplar (*Populus* sp.) and black locust (*Robinia pseudoacacia* L.).

Year-over-year analysis demonstrates the varying extents and intensities of reforestation efforts, providing insights into the dynamic nature of these initiatives. These findings can inform more detailed analyses that support forest management plans, thereby contributing to enhanced afforestation strategies and subsequently expanding forested areas.

Keywords: afforestation, private forests, restoration, state forests

Introduction

Afforestation can transform vulnerable forests into diverse, productive, and climate-resilient forests (Bolte et al., 2009; Reyer et al., 2015). Increasing forest area through afforestation is not only desirable but also mandated by the Law on Forestry ("Official Gazette of the Republic of Serbia," Nos. 30/2010, 93/2012, 89/2015, and 95/2018). Article 80, paragraph 1, specifies that the budget of the Republic of Serbia, as well as the budget of autonomous provinces, must allocate funds for measures aimed at "increasing the degree of

forest cover through afforestation." Also, meliorative measures, in addition to increasing the quality of forests, imply stopping degradation and reducing the surface of degraded lands, they should take into consideration the application of afforestation technologies, which guarantee satisfactory success while optimizing costs (Isajev *et al.*, 2010).

In the context of adapting to and mitigating climate change, afforestation is a crucial tool. It is especially important in modern conditions, considering that it is a cost-effective and easily accessible option for mitigating the negative effects of climate change. In this context, the economic potential of afforestation as an adaptation strategy to climate change and its role in mitigating climate change was assessed before using dedicated forestry models and integrated assessment models (Calvin *et al.*, 2014; Humpenöder *et al.*, 2014; Doelman *et al.*, 2020, etc.). It is of great importance that afforestation can be used as a tool that can be actively used to mitigate climate change through carbon sequestration.

At the beginning of the 19th century, forest coverage in Serbia was around 3,300,000 ha, and in 1912, the area of Serbia was 4,830,260 ha, which represents about 2/3 of the territory under forest (Vučićević, S., 2008). The attitude towards forests at the beginning of the 19th century led to Serbia having 1.5 million ha under forests at the beginning of the 20th century. In 100 years, about 1.8 million ha of forest area was removed. According to the data of the Ministry of Agriculture, Forestry and Water Management – Directorate of Forests of the Republic of Serbia, the trend of increasing areas under forest is going in a positive direction (<https://upravazasume.gov.rs>).

Previous authors who analyzed the trend of afforestation in the Republic of Serbia point to a pronounced negative trend of forested areas in the 21st century. In the period 2002-2021, the afforested area decreased by 5.39% on average per year, with 5.71% for broadleaves and 4.70% for conifers (Ćirković-Mitrović *et al.*, 2022). This happened to the greatest extent as a consequence of reduced investments in forestry (Ivetić, 2015). Along with the negative trend of afforestation, a big problem is the success of the implementation of these measures, which has been significantly reduced due to inadequate afforestation technology and the implementation of silvicultural measures after the afforestation (Ivetić, 2015).

Considering the previously mentioned observations, this paper aims to analyze the trends in afforestation across various periods and tree species.

Material and Methods

The afforested area data from the Republic Institute for Statistics of the Republic of Serbia were analyzed. Two distinct periods were examined, along with the entire 14-year span, which served as the basis for predictions for the period 2024-2028. The first period covers 2010 to 2016, and the second spans 2017 to 2023.

The analysis includes beech (*Fagus sylvatica* L.), oak (*Quercus* sp.), poplar (*Populus* sp.), black locust (*Robinia pseudoacacia* L.), as well as other broadleaves. In case of conifers the analysis was performed for spruce (*Picea* sp.), fir (*Abies alba* Mill.), Scots pine (*Pinus sylvestris* L.), Austrian pine (*Pinus nigra* L.), Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), larch (*Larix* Mill.), and other conifers.

The collection of data for the specified studied period of 14 years, was adequately sorted within the Microsoft Office software package.

Sorting was done into 4 regions: Belgrade, Vojvodina, Šumadija and Western Serbia, and Southern and Eastern Serbia region. The data was compiled based on the specified types of trees and a division was made based on ownership into the private and state sectors. The data sorted in this way were processed and the results were presented in the form of graphs with associated explanations.

Results and discussion

Forest resources represent the basis of our lives and the entire economic activity. Their depletion is a major challenge for the economic development of both developed and developing economies (Singh et al. 2024). Afforestation efforts on degraded lands positively affect various soil properties and improve general habitat conditions (Korkanç, 2014). It is also of great importance that afforestation (artificial regeneration and establishment of new forests) causes fundamental changes in the structure and functioning of ecosystems, including changes in available light, microclimate, production, nutrient cycling, and water balance, all of which can affect biodiversity (Elmarsdóttiret et al. 2008).

The volume of afforestation for the period 2010–2016

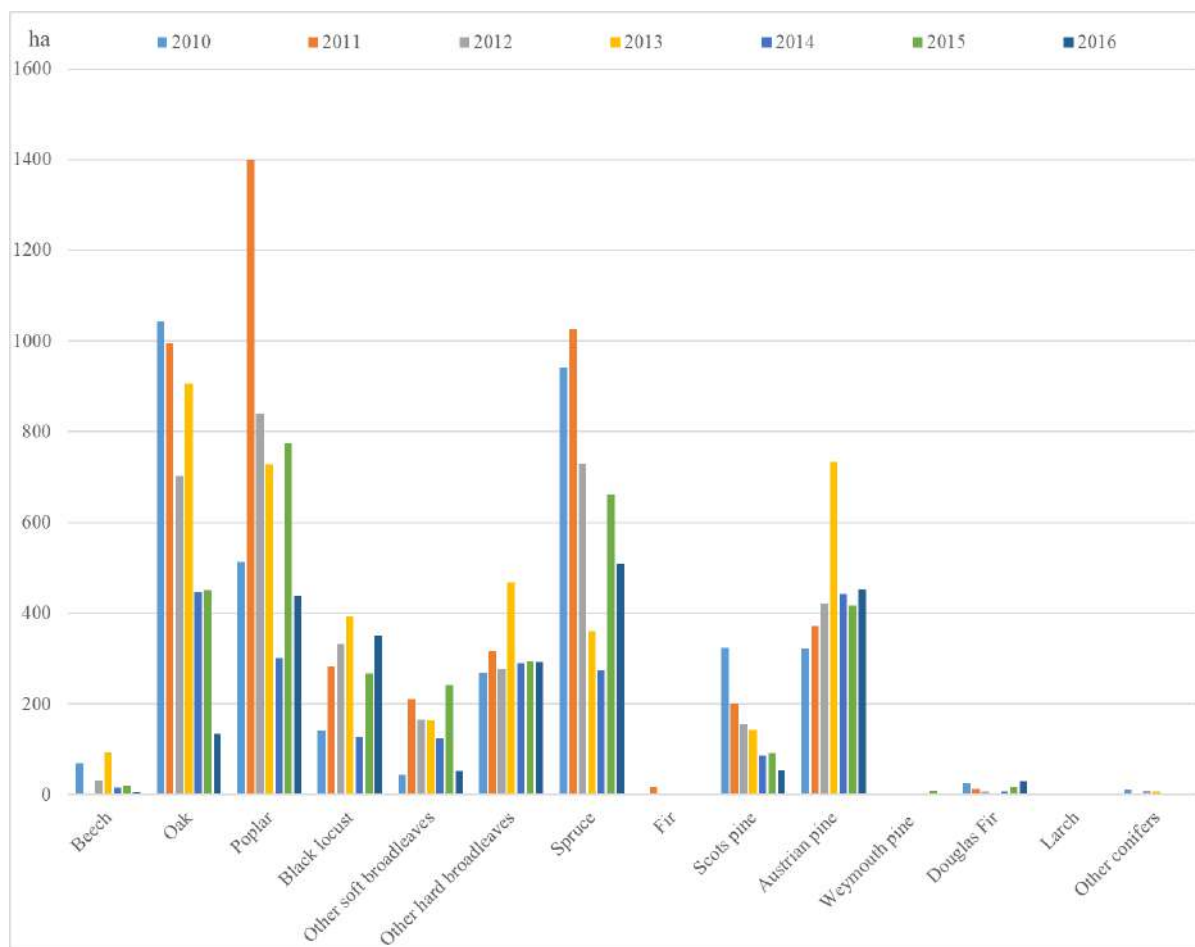


Figure 1: Presentation of the results of the volume of afforestation in hectares for the period 2010-2016

Figure 1 shows the dynamics of afforestation of different types of trees for the period 2010-2016. A total of 23920 ha was reforested, of which 20792 ha in the state sector and 3128 ha in the private sector. On average, 3417.15 ha of afforestation was realized annually. In all types of trees, except for Austrian pine, black locust, and Euroamerican poplars, a trend of decreasing the volume of afforestation is observed, which is in line with the general trend of decreasing the afforested area.

The most intensive afforestation with broadleaves species was carried out in the areas where afforestation was planned with oaks and poplars, while the least afforestation was carried out in places where beech and black locust were planned. In conifers, the largest area is forested with spruce and Austrian pine, and the smallest with larch and Weymouth pine.

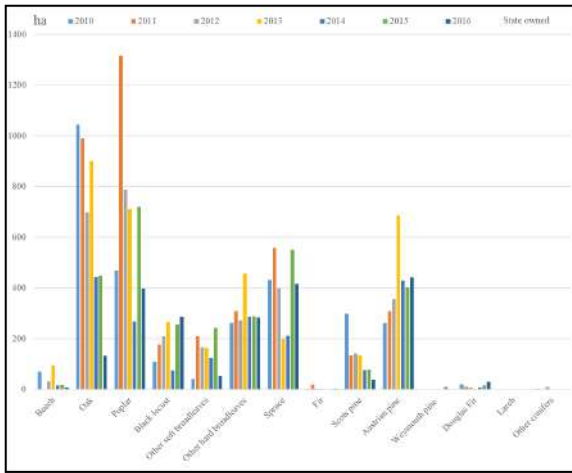


Figure 2: Presentation of the results of the volume of afforestation in hectares for the period 2010-2016 in state-owned sector

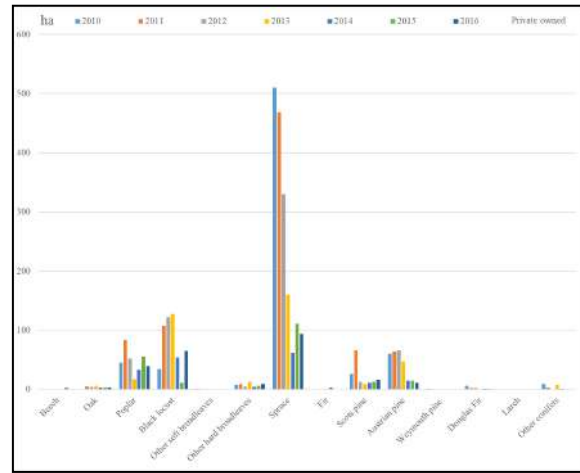


Figure 3: Presentation of the results of the volume of afforestation in hectares for the period 2010-2016 in private-owned sector

Figure 2 and 3 present differences in state-owned and private-owned sectors for period 2010-2016. There is significantly larger amount of afforested area in state-owned sector compared to the private sector. Afforestation efforts in the state-owned sector are more diverse and focused on long-term sustainable species, whereas the private sector primarily focuses on spruce and black locust, likely due to their resilience and suitability for specific terrains.

The volume of afforestation for the period 2017–2023

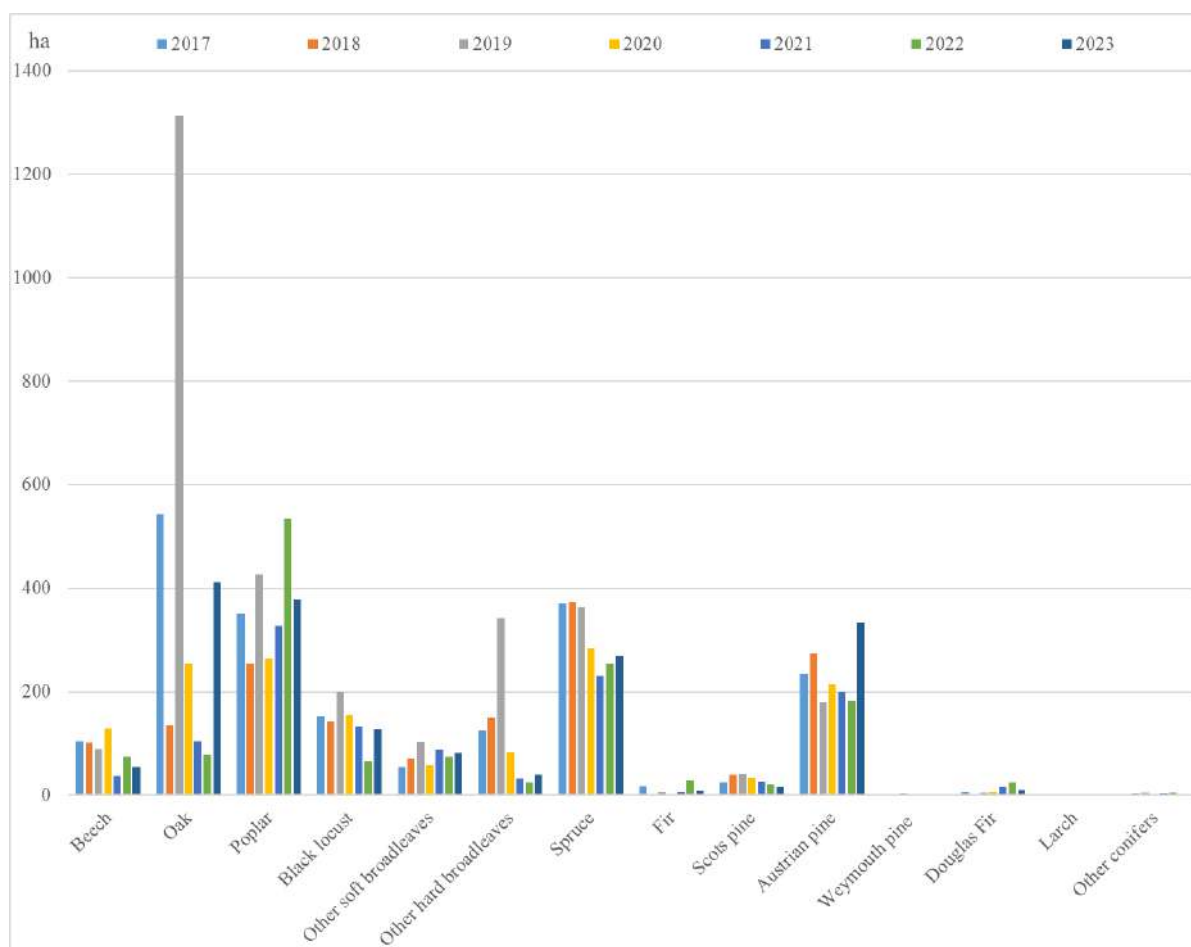


Figure 4: Presentation of the results of the volume of afforestation in hectares for the period 2017-2023

Figure 2 presents the dynamics of afforestation of different types of trees for the period 2017-2023. In that period, a total of 12,386 ha was reforested, of which 11,807 ha were in the state sector and 579 ha in the private sector. On average, 1769.42 ha of afforestation were realized annually. As in the case of the previous analyzed period, in all types of trees, except for Austrian pine, black locust, and Euroamerican poplars, there is a noticeable trend of decreasing the extent of afforestation. The intensity of afforestation in the areas is identical to the period 2010-2016. The largest percentage of afforestation areas belongs to oaks and poplars, the smallest to beech and black locust, among conifers the highest percentage also belongs to spruce and Austrian pine, while the smallest percentage belongs to larch and Weymouth pine.

This is in accordance with the general trend of afforestation in Serbia, that is, the use of Euroamerican poplars dominates to manage forests with a short rotation and pronounced economic benefits. In addition, black locust has proven to be a very practical species for afforestation of hilly areas, while Austrian pine is dominantly used on inaccessible and erosive terrains, and generally hilly and mountainous terrains.

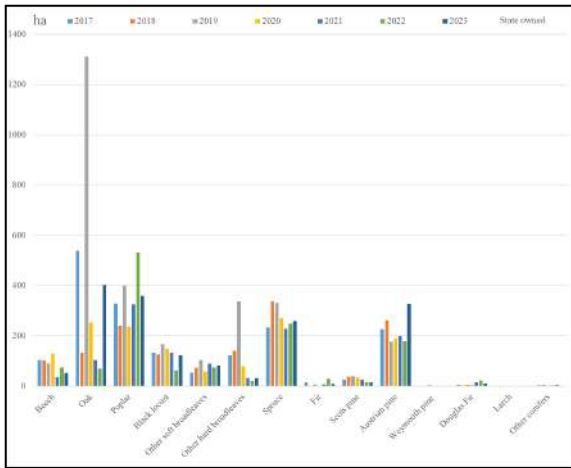


Figure 5: Presentation of the results of the volume of afforestation in hectares for the period 2017-2023 in state-owned sector

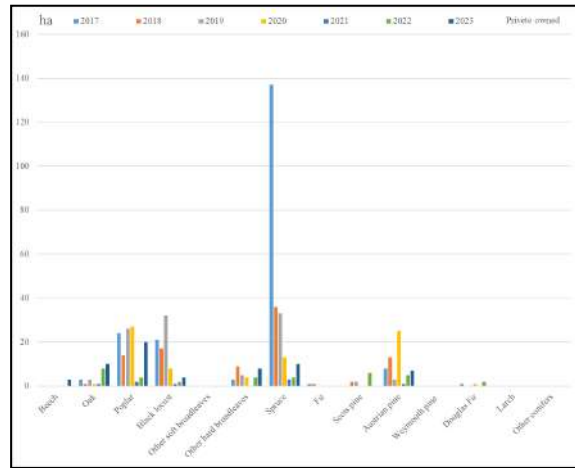


Figure 6: Presentation of the results of the volume of afforestation in hectares for the period 2017-2023 in private-owned sector

Figure 5 and 6 present differences in state-owned and private-owned sectors for period 2017-2023. Similar to the 2010–2016 period, there is a significantly larger afforested area in the state-owned sector compared to the private-owned sector. In the state-owned sector, the data indicate a slight change in species selection for afforestation purposes. Compared to the 2010–2016 period, the usage of poplar has decreased, whereas the usage of oak has increased. In the private-owned sector, there are no significant changes, with the usage of spruce still being dominant.

Conclusion

Within the period 2010-2016, a total of 23920 ha was reforested, of which 20792 ha in the state sector and 3128 ha in the private sector. On average, 3417.15 ha of afforestation was realized annually. In the period 2017-2023, a total of 12,386 ha was reforested, of which 11,807 ha were in the state sector and 579 ha were in the private sector. On average, 1769.42 ha of afforestation were realized annually.

Data from this paper can be summed up in few categories:

1. Dominance of certain tree species:
 - Broadleaf species like oaks and Euroamerican poplars dominate afforestation efforts, highlighting their economic importance and adaptability to short-rotation forestry practices.
 - Among conifers, spruce and Austrian pine are the most commonly used species, likely due to their resilience and suitability for specific terrains.
2. Sectoral distribution:
 - The majority of afforestation is within the state-owned sector, accounting for a significant portion of afforested areas in both periods. The private-owned sector's contribution remains relatively small but consistent.
3. Species-specific trends:
 - Species such as black locust, Austrian pine, and Euroamerican poplars showed an increase in afforestation, contrasting with the overall decline for other species.
 - Black locust is favored for its practicality in afforesting hilly regions, while Austrian pine is suited for mountainous and erosive terrains.

These trends emphasize the need for a balanced afforestation strategy that considers ecological sustainability, economic viability, and the challenges posed by decreasing total amount of afforested areas.

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