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Silvicultural Practices in the Process of Climate Change in Turkish Forests

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Abstract: Forests are important ecosystems in mitigating the effects of climate change and combating climate change. Forests, which are the most important renewable energy sources, are the largest carbon pool after the oceans. Türkiye's forests, which are spread over three different plant geographies, are densely forested areas where arid and semi-arid climatic conditions are observed and which may be sensitive to climate change stress. On the other hand, forest fires in the Mediterranean basin also pose a significant threat to Turkish forests. Within the scope of combating climate change, it is important to prevent deforestation, to preserve the natural stand structures in existing forest areas, to improve the growth and increment characteristics of stands under appropriate stand structures to the extent permitted by the growing environment characteristics of the stands. Guaranteeing natural regeneration conditions through stand tending works and preferring natural regeneration in forest areas where it is possible are important principles of silviculture. On the other hand, there is an important amount of forest area in the Turkish forests where the canopy is none or degraded and which should be subjected to rehabilitation and restoration works in this context. In today's world where habitat and forest area losses are experienced, it is of great importance to carry out pioneering studies to protect forest genetic resources against climate change, to carry out tree breeding studies and to eliminate the problem of seed migration that may occur in the future due to climate projections. Silvicultural techniques, depending on the sustainable management approach in forestry, constitute an important assurance within the scope of combating climate change. Forest tending works are very important for forests to act as an important carbon sink. Mixed stands in which broad-leaved species are also included in the mixture sequestrate more carbon than pure stands. Especially the presence of individuals with thick diameters in the stands increases the carbon sequestration even more. The duration of the rotation period in even-aged stands and the length of the rotation period in uneven-aged stands are determinant in the amount of carbon sequestration of forest ecosystems. The repetition time and intensity of silvicultural treatments are also directly affected carbon sequestration. In this study, general evaluations were made about the silvicultural practices that should be concentrated in order to increase carbon sequestration in forest areas in Türkiye, the issues that should be considered in practice in stands were evaluated and recommendations were made considering future projections.

Keywords: Forest, Climate change, Silviculture, Carbon sequestration.

1. INTRODUCTION

Since the 1950s, the warming of the climate system has accelerated and many of the observed changes such as warming of the atmosphere and oceans, decrease in snow and ice, rise in sea water level, increase in greenhouse gas concentrations are taking place at an unprecedented rate (IPCC, 2014). Especially in recent years, there has been an increase in greenhouse gas emissions due to reasons such as urbanisation, land use change, deforestation and industrialisation. The increase in greenhouse gases in the atmosphere has led to the emergence of many problems. As a result of global warming, it is stated that biodiversity will be negatively affected together with humans in the future (Verburg et al., 1999; Wakeel et al., 2005). Türkiye is located in the Mediterranean basin, and it is one of the regions that will be affected highly from climate change, temperature increase, water scarcity, drought, etc. It is possible to say that this situation affects the living organisms and socio-economic sectors living in the region.

Forests' role in climate change is two-fold. They act as both a cause and a solution for greenhouse gas emissions. Around 25 per cent of global emissions come from the land sector, which is the second largest source of greenhouse gas emissions after the energy sector. Deforestation and forest degradation account for about half of the greenhouse gas emissions from the land sector. On the other hand, forests are also one of the most important solutions to mitigate the effects of climate change. Therefore, increasing the amount of forest areas and sustainable management of forests are very important in order to minimize the effects of climate change. In this case, planning new perspectives in forestry, including silvicultural approaches, is very important in reducing the future effects of climate change. At the same time, new models should be created by taking risk factors into account in planning (IUCN, 2021). In order to guarantee the continuity of the products and services provided by forest ecosystems, it is very important to complete the technical, social and economic infrastructure works necessary for achieving new forest areas as well as improving the vital quality of existing forests (Pretzsch et al., 2002; Zell, 2016).

In the recently published "State of the World's Forests" report, it is stated that forests cover 31% of the world's terrestrial area with a total area of 4.06 billion hectares, and 7% of forest areas with 294 million hectares consists of afforestation (FAO, 2022). In Türkiye, the forest area is 23,2 million ha and the forest area per capita is 0.27 ha Moreover, the ratio of forest areas to terrestrial areas in Türkiye is around 29,4%. However, the total forest area with a degree of closure of 10 percent and above constitutes a total of 13.7 million hectares according to economic, ecological and socio-cultural function distinctions. Full compliance with natural regeneration methods is not possible in approximately 3 million hectares of the total 13.7 million hectares of forest area with a degree of canopy closure above %10 (OGM, 2022). Approximately 1,2 million hectares of forest land, devoid of tree cover and without canopy, have been transformed into productive forest areas within a period of twenty years between the years 1999 and 2000. However, forestry authorities state that the current 9.7 million hectares of forest land has the potential to be transformed into ecologically productive forests. So, support from artificial rejuvenation, afforestation, rehabilitation and restoration workings are needed in Turkish forestry.

In this study, general evaluations were made about the silvicultural practices that should be concentrated in order to increase carbon sequestration in forest areas in Türkiye, the issues that should be considered in practice in stands were evaluated and recommendations were made considering future projections.

2. IMPORTANCE OF SILVICULTURE IN THE PROCESS OF CLIMATE CHANGE

Management of existing forest dynamics through successful regeneration efforts has a very important role in the sustainable management of forests, which are of great importance in preventing carbon sequestration and climate change. In this sense, it is necessary to examine the ecological conditions of the growing environment in detail, to determine and monitor both short-term and long-term climatic changes. This is also important in terms of analysing and evaluating the regional differences and impacts of climate change (Koenig et al., 2015).

Natural and artificial regeneration workings alone are not sufficient to ensure the sustainability of forests. It is very important to regulate the increment-growth relations in the stand at an optimum level with all maintenance workings applied in the stand after regeneration in order to achieve the best management goals. Thus, the level of benefit of the trees in the stand from the existing ecological opportunities will be maximized. As a matter of fact, global warming and its effects can have significant effects on the natural succession in the ecological unit area, as well as cause the processes to end significantly. Therefore, individual developments in the stand should be closely monitored after regeneration. Even regeneration and maintenance workings should be revised when necessary depending on climate change effects on the habitat (Bogdziewicz et al., 2021). If the potential negative effects that may arise after climate change are not completely eliminated, it will be possible to construct stands that are more resistant to adverse conditions in the forest ecosystem with new silvicultural approaches.

Considering the effects of climate change, the symbiosis between living organisms forming the forest ecosystem may weaken and species may move horizontally and vertically towards ecological unit areas with more favourable growing environment conditions due to the stress factor. This change may manifest itself as a change in the number of species forming the population or a change in the composition of the species forming the forest community. An increase in the number of invasive species can be observed (Gougherty et al., 2021; Stockdale et al., 2019; Varol, 2023; Ayan et al., 2022; Aitken et al., 2008; Brewer et al., 2002; Magri et al., 2006). Changes in the distribution range of tree species (Watling et al., 2015), shifts of tree species to northern regions and higher altitudes, as well as significant declines in biodiversity and ecosystem functioning are among the consequences of climate change. However, forest growth is increasing rapidly in some mountainous regions (Silva et al., 2016). Although the establishment of new forests in some regions is a beneficial consequence of climate change, in contrast to other regions, climate change can lead to deforestation and geographical change with seed migration and even species extinction (Taleshi et al., 2019). In this context, the selection of species and origins resistant to stress factors and studies in this field are of great importance. The most important features that increase the adaptation of a forest area to climate change are species composition, the self-renewal power of species, the presence of destruction processes in natural succession, richness in terms of genetic diversity, and the width of the distribution areas of species horizontally and vertically, the richness and frequency of the abundant seed year, the ability of the seed to fly, the resistance of the species to drought stress, the percentage and speed of seed germination, the tendency of the formed young to be tolerant to the ecological conditions of the growing environment and whether the species has a pioneer tree character (Johnston et al. , 2006; Aitken et al., 2008). It would not be misleading to think that the stands formed by tree species that meet these criteria will be among the forest areas that are less likely to be affected by future climate projections in terms of adaptation to climate change. Therefore, the use of these forest areas as a seed source and the use of tree species with these characteristics in the rehabilitation of deforested or degraded forest areas will be beneficial in the establishment of forest areas resistant to climate change. In order to grow forests with the highest yield in terms of quality and quantity in accordance with the demands of the economy by utilising the hereditary characteristics and variations of the species in afforestation studies, the use of seeds obtained from improved seed sources in appropriate areas is foremost. However, seed and sapling quality is also of great importance in afforestation works. In addition to the determination of morphological characteristics of seeds and seedlings, determination of physiological characteristics such as determination of frost and drought resistance in seeds and seedlings is important for success in afforestation (Kaplan et al., 2023).

Silvicultural practices carried out in forest resources not only cause significant changes in the dynamics of forests, but also have significant effects on macro and micro fauna and other vital elements, which are important elements of the forest ecosystem. In this context, considering the effects of climate change, the results of silvicultural practices should be evaluated in terms of forestry and silvicultural techniques, as well as in combination with the effects of global climate change. Terrestrial and aerial tracking and monitoring systems should be used in these evaluation studies (Thrippleton et al., 2018). Moreover, conversion of coppices into groves, rehabilitation of degraded forests and increase in youth are also known to have a positive effect on carbon sequestration (Tolunay, 2011).

Forest resources sometimes suffer irreversible and irreparable damages in events that occur based on both anthropogenic impact and natural processes and have many negative effects on forest resources. In this sense, climate change and global warming always have significant effects on the formation, increase or decrease of the effects of many harmful factors, especially snow, storm, wind, fire, insect and fungal damages. This situation closely affects and changes forest dynamics. For this reason, the new generation at different ages should be evaluated with the help of modelling and the effects of global warming should be revealed objectively (Dyderski et al., 2018).

In Türkiye, forest fires are mostly observed in the Aegean, Mediterranean and Marmara regions. Seasonal climatic elements such as temperature, precipitation, relative humidity and wind create a favourable environment for fires (Doganay & Doganay, 2004). Human-induced fires also occur. However, climate change and population density in areas with fire risk cause the risk to always exist. In order to minimise the damage of forest fires, it is recommended to make forests more resistant to fire risk and to adopt fire management planning (Avcı & Korkmaz, 2021).

One of the important effects of global warming is pollination, fertilisation and seed formation, which is one of the vital processes of forestry. Serious interruptions in this important process always cause serious interruptions in the formation and shaping of future generations in forests. In this direction, no matter how successful silvicultural techniques are applied, inefficient progeny formation and inability to transfer genetic material to future generations due to the effects of global warming always minimise the level of success. For this reason, researches revealing the effects of climate change on gene flow and transfer in our country, especially in our forests, should be supported in this sense (Burkhart & Tome, 2012).

3. CONCLUSION

As a result of the evaluations made, it is possible to say that in growing environments where an increase in drought stress is observed due to climate change, it is absolutely necessary to use the shelterwood system effectively among natural regeneration methods. While planning the regeneration works with shelterwood system, both for increasing the mast capacity and for protecting the seedlings from the sun effect during the first few years, canopy closure should be increased by 10% in accordance with the biology of the tree species, especially in the southern aspects during the seed cutting phase. Again, in these growing environments, repetitive overhead release felling should be made gradually and the biological independence processes of the young generation should be carried out in coordination. Size of the regeneration areas in Turkish red pine, which shows great success in clear cutting system due to its biology, should be re-evaluated depending on the climate change process. In this context, it may be recommended not to apply clear cutting system in areas larger than 1-3 hectares. In artificial regeneration workings and in afforestation areas, the most resistant individuals to stress conditions should be included in the stand composition and new forest areas resistant to external influences should be established by planting saplings with high genetic gain obtained after determining suitable origins. The growth of individuals with healthy growth tendency should be supported by appropriate tending workings (tending during the thicket stage and cleaning) without delay by removing the individuals with negative selection principles. In line with the principles of negative selection, it should be avoided as much as possible from approaches that are based on the distribution of individuals at equal distances in the unit area by subjectively selecting individuals that do not have negativity indicators. It is very important that the stand closure is kept at 0.8-0.9 levels and that the stands are located under the normal density level. Until the end of the management period, regardless of the biology of the stands, it should be ensured that this degree of closure and normal density should be maintained during thinning. In the case of stands of suitable tree species, the value increase or reserve management must be deducted. Pruning should be carried out in young stands to support biomass increase. In the rehabilitation of burnt forest areas, the formation of natural stand compositions should be supported. When necessary, rehabilitation works that will enable the transition from pure stands to mixed stands should be supported in order to increase biodiversity and support the formation of fire-resistant forests. In the rehabilitation of forest areas with decreased productivity, the point of view of ignoring the trees with damaged trunks depending on the wood production efficiency and removing them from the area by cutting, and planting sapling material that can produce qualified wood production in their place brings some drawbacks. It is clear that old trees have an important carbon sequestration capacity with their deep root structures. Therefore, they should be kept in the area regardless of their wood quality, provided that they are absolutely healthy in rehabilitation works. Taking into account the horizontally and vertically changing distribution areas of the species in line with future climate projections, it is of great importance for future forestry strategies to establish pioneer populations and monitor their development in line with the approaches of transferring the genetic material required to increase the resistance of forest ecosystems to climate change from other regions.

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