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Effects of Silvicultural Interventions on Carbon in High Mountain Forests in Türkiye

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Abstract: High montane forests are defined as forests between high montane (oreal) and subalpine ranges, which are under pressure against extreme climatic conditions and anthropogenic influences and have difficulty in regenerating themselves under these conditions. High montane forests, which are constantly struggling with poor growing environment conditions, have difficulty in regenerating themselves and cannot respond to the forestry activities implemented. However, due to unfavorable terrain and climatic conditions, carbon accumulation in both subsoil and above-ground vegetation in high mountainous areas remains in very low amounts. Therefore, silvicultural interventions that can be applied by increasing the carbon stock capacity of high mountain forests and revitalizing the ecological role of high mountain forests should be done in accordance with their nature. In order to increase the amount or potential of carbon storage, conservation and sustainable use of forest ecosystems are important for combating climate change and global carbon balance. Therefore, special planting practices should be implemented in high mountain forest areas to accelerate carbon storage. As a result, the potential production, biomass increase and carbon sequestration capacity of high mountain forest areas can be better utilized. Within the scope of this study, the effects of silvicultural interventions on carbon in high mountain forests in Türkiye will be evaluated.

Keywords: Carbon storage, Carbon sequestration, Silviculture, High mountain forest, Special planting practices.

1. INTRODUCTION

High mountain forests are understood as forests located on the high mountain forest step, which have unique biological, physiological, sociological and growing environment characteristics, which can survive under extreme living and existence conditions, and which react very significantly to destruction (Çolak & Pitterle, 1999). High mountain forests, which are constantly struggling with poor growing environment conditions, have difficulty in renewing themselves and cannot respond to forestry activities. Therefore, it is very important to know the forest boundary in order to protect these forests and to restore the disturbed balances (Yücesan et al., 2014). The concept of forest boundary constantly varies against microclimatic effects and creates transition zones. In general, when moving from the forest to the alpine and polar zones, it is seen that the closure of the forest deteriorates first and then the tree height shortens (Figure 1). This phenomenon is typical for undisturbed borders. In this zone, three boundaries are distinguished as "forest boundary", "tree boundary" and "crippled tree boundary" and the part between the forest boundary and the tree boundary is called "battle zone" (Saatçioğlu, 1976).

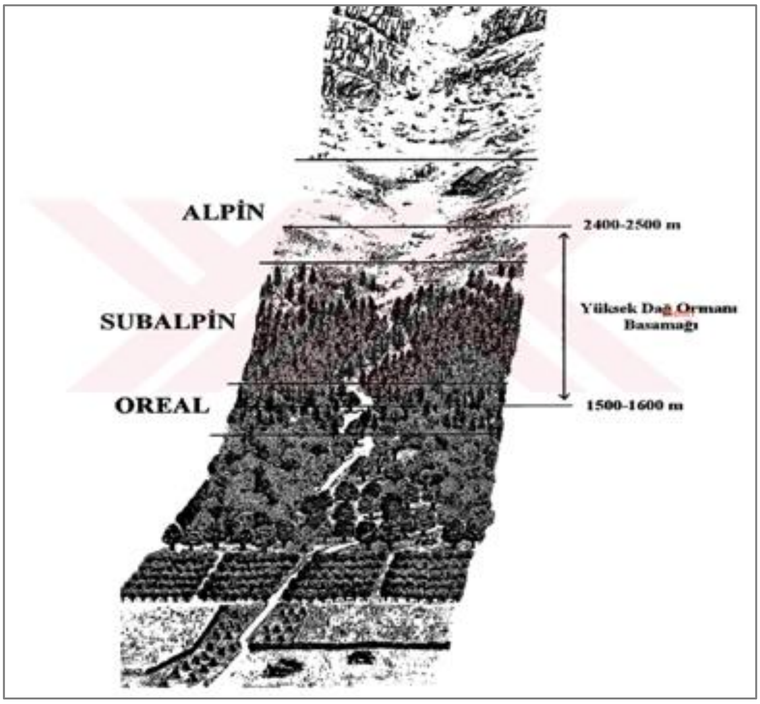

Figure 1. High mountain forest step (Sag, 2002).

The height difference between the forest boundary and the tree line is often 100-150 m (Yücesan, n.d.). The forest in the war zone has become vulnerable to many factors and the forest structure has deteriorated. The most important reasons for this deterioration are the slope due to the altitude, erosion and the rocky nature of the forested areas. The fact that the mountain forest boundary is close to the plateau areas causes it to be under constant threat by human beings. With the opening of many plateaus to tourism and animal grazing, the battle zone has disappeared and the forest boundary has been destroyed. In this context, harsh ecological conditions and anthropogenic impacts will continue to prevail in high mountainous areas and will continue to push the potential forest boundary downwards (Üçler, 2002). Therefore, due to unfavorable terrain and climatic conditions, carbon accumulation in both subsoil and above-ground vegetation in high mountain areas remains very low. Therefore, the carbon stock capacity of high mountain forests needs to be increased. For this reason, forest form should be created in accordance with its nature. Forests are the most important renewable energy sources and constitute the largest carbon pool (Mısır et al., 2015).

The climate factor is very important for forests to grow up to a certain elevation in mountainous areas (Yücesan, 2000). Especially climate change has a negative impact on forests. It pushes the forest boundary in high mountainous areas towards the lower slopes. Therefore, in order to reduce the impact of climate change on forests and protect biodiversity, silviculture studies should be carried out in accordance with their nature (Valencia, 2019). In this context, the continuity of the dynamics of forests, which have a very important function in preventing climate change and mitigating its negative effects, including carbon storage, should be ensured**.**

Special planting practices should be implemented in high mountain forest areas to accelerate carbon storage. As a result, the potential production, biomass increase and carbon sequestration capacity of high mountain forest areas can be better utilized.

2. SPECIAL PLANTING PRACTICES IN HIGH MOUNTAIN AREAS

Since high mountain ecosystems cannot fulfill some of their functions in the upper zones of forests due to unfavorable conditions, the afforestation techniques that should be applied in these areas should be very different from the afforestation techniques applied in the lower zones of forests (Çolak & Pitterle, 1999). For this reason, afforestation of high mountainous areas falls under the category of afforestation for conservation purposes (Anonymous, 2004).

Microclimatic influences and soil condition play an important role on the planting spacing of upland plantations. In such locations, natural young growth is consistently characterized by clusters (Schönenberger, 2001; Schönenberger et al., 1990). Therefore, many saplings collectively coexist in suitable locations at irregular intervals (Schönenberger, 1978). Thus, in high mountainous areas, cluster afforestation should be preferred over regular and widely spaced afforestations (Brang et al., 2004, Schönenberger, 2001, Yücesan, 2006; Schönenberger & Wasem, 1999). Before afforestation works are carried out, the area to be afforested should be well analyzed and some precautions should be taken (Yahyaoğlu & Ölmez, 2006). First of all, a small growing environment suitable for afforestation should be determined. Then, land preparation should be started with terracing, tripod stakes, trunks extended parallel to the equal elevation curves to prevent avalanches against snow movements and strong wind effects in the determined growing environments (Çolak & Pitterle, 1999). After these preparations are completed, according to Schönenberger (2001), the space between tree collectives should be planned so that two collectives do not merge. In cluster plantations, plantings should be carried out in the form of collectives consisting of 20-30 saplings with a diameter of 2-4 meters. The saplings to be used in afforestation should be planted 50-100 cm apart, close to each other. The clusters should lie in an oval shape and perpendicular to the wind direction. For this reason, the collective length should be planned between 10-15 m and the collective width between 8-15 meters. Thus, small tree collectives in high mountain areas will form the targeted cluster unit within 20-30 years (Schönenberger, 2001) (Figure 2), (Figure 3).

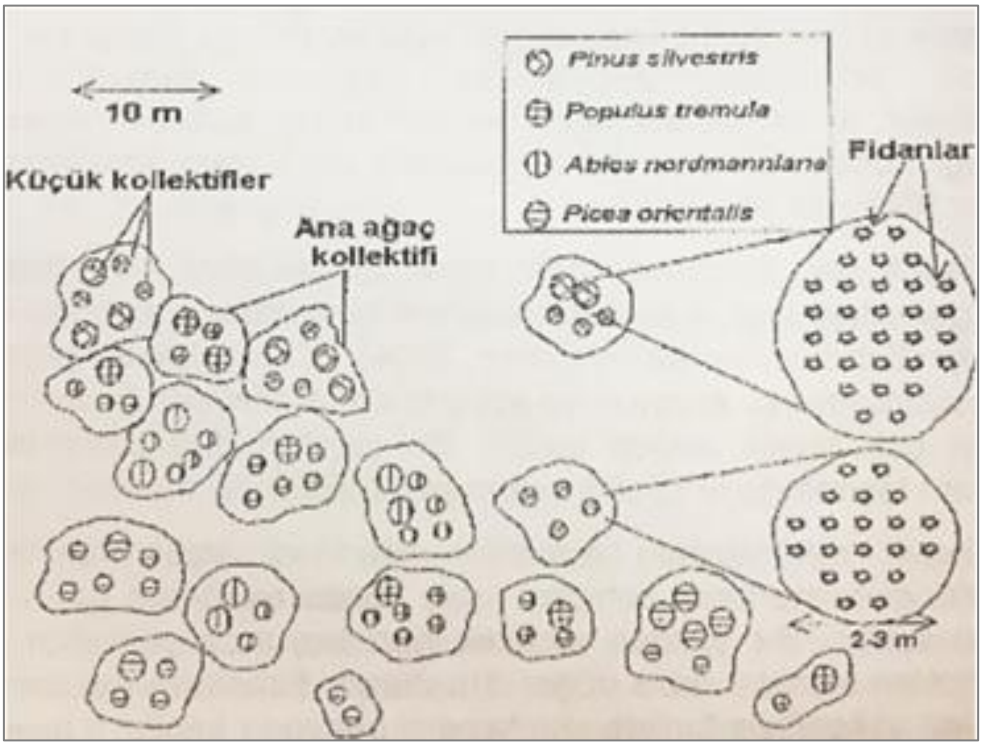

Figure 2. Theoretical schematic layout of 17 cluster plantations of 20-30 saplings (Schönenberger, 2001 cited in Yahyaoğlu & Ölmez, 2006).

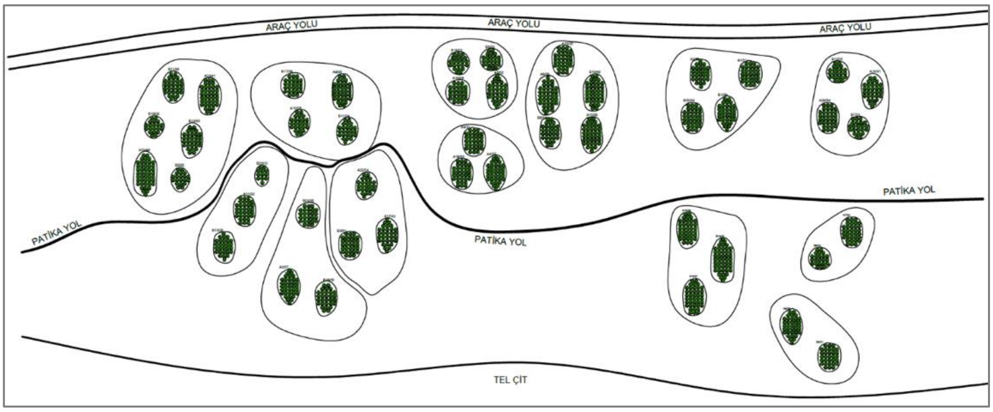

Figure 3. Terrain model of eastern spruce (*Picea orientalis* L.) cluster afforestation in the subalpine zone (Kalender, 2020).

3. CONCLUSION

It is seen that the primary factor in carbon storage is to slow down and prevent deforestation and to afforest high mountainous areas in accordance with their nature. Considering such benefits, it is understood that cluster afforestation should be used to increase the planting success and carbon amount in afforestation in high mountain areas. As a result, potential production, biomass increase and carbon sequestration capacity can be better utilized by cluster afforestation in high mountain forest areas. With cluster afforestation in high mountain areas;

- Cluster afforestation in degraded areas in high mountainous areas helps to sequester carbon in the soil by preventing floods, floods, avalanches and landslides.
- Forests play an important role in combating climate change by sequestering more carbon than other ecosystems. Cluster afforestation in high mountainous areas will increase the amount of carbon by creating a forest form.
- High mountainous areas have extreme climatic conditions. Therefore, by using appropriate species in the afforestation works to be carried out, both subsoil and above-soil carbon sequestration capacity will be better utilized.

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